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MELVILLE T. COOK, Editor.

THE CERCOSPORAE OF PUERTO RICO
RAFAEL A. TORO.

NOTES ON BIRDS OBSERVED AT GUANICA LAGOON, PUERTO RICO
HARRY A. BEATTY.

PUERTO RICAN ORNITHOLOGICAL RECORDS
STUART T. DANFORTH.

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THE CERCOSPORAE OF PUERTO RICO

RAFAEL A. TORO

The following list of Porto Rican Cercosporae represent a rather exhaustive examination of the literature in which references to Porto Rican fungi occur as well as a study of specimens deposited in the extensive collections of Porto Rican fungi in the Herbarium at Cornell University and the New York Botanical Gardens. The author believes this list to be fairly complete. The collections begin with Holler in 1902 and continue with those of Stevenson, Whetzel, Olive, Chardon, Stevens, Seaver, Barrus, and the writer up to the present time. The numbers one to fifteen following the name of the host refer to the citations given cle. The numbers in **bold face type** refer to t Where the names of the collections are not g umbers in the herbarium at Cornell Univers species which are listed as in the Herbariur linois were copied from the material found in the New York Botanical Garden collection. The reference cited in each case is to the original place of publication of the species. The species indicated by asterisk (*) are new reports for the Island.

I wish to acknowledge the suggestions and assistance of Dr. Charles Chupp and Professor H. H. Whetzel, of Cornell University, in the preparation of this list, and to the former for the descriptions of the three new species, and the critical notes on various of the specimens which he examined.

CERCOSPORA Fries

1. CERCOSPORA ACHYRANTHIS Sydow, Ann. Myc. **7**:171. 1909.
   On *Centrostachys aspera* (L) Standley 8, 9, 13; **464**; Herb., Univ. of Ill. **333, 459, 459** *a*.

2. CERCOSPORA ACROCOMIAE Stevenson, Ann. Rept. Ins. Exp. Sta. Porto Rico **1916**:89. 1917.
   On *Acrocomia aculeata* (Jacq.) Lodd 8, 13; Stevenson **2090**.

3. CERCOSPORA ALTERNANTHERAE Ell. & Lang., Journ. Myc. **6**:36. 1890.
   On *Achyranthes portoricensis* (Kuntze) Standley 8, 9, 13; Herb. Univ. of Ill. **820, 3273, 3976, 8479**.

4. CERCOSPORA AMARYLLIDIS Ell. & Ev., Journ. Myc. **3**:14. 1887.
   On *Hymenocallis* sp. 15; Herb. Univ. of Ill. **836**
   H. declinata (Jacq.) M. Roem. 8, 13.

5. CERCOSPORA ATRICINECA Heald & Wolf, Mycol. **3**: 14. 1911.
   On *Crassina elegans* (Jacq.) Kuntze. 8, 13;
   Zinnia sp. 9.

6. CERCOSPORA BERNARDIAE Stevens, Trans. Illinois Acad. Sci. **10**:213 1917.
   On *Bernardia Bernardia* (L) Millsp. 8, 9, 13; Herb. of Univ. of Ill. No. **355**A.

7. CERCOSPORA BETICOLA Sacc., Nuov. Giorn. Bot. Italia **8**: 189. 1876.
   On *Beta vulgarus* L. 8, 9, 13, 14.

8. CERCOSPORA BIFORMIS Peck, Bull. Torrey Bot. Club **36**:156. 1909.
   On *Passiflora sexflora* Juss. 8, 9, 13.

9. CERCOSPORA BIXAE Allesch & Noack., Bot. Inst. Agron. do Estado de Sao Paulo em Campinas **9**:95. 1898.
   On *Bixa orellana* L. 8, 9, 13; **1180**; Herb. Univ. of Ill. **56, 3795, 4845**.

10. CERCOSPORA BLOXAMI Berk. & Br., Annals and Mag. Nat. Hist. Ser. 5. **9**:183. 1882.
    On *Brassica* spp. 8, 11; Univ. of Ill. Herb. **449, 5121**.
    B. rapa L. 11, 13, 15;
    B. napus (L) 15;
    B. arvensis L 13;
    B. integrifolia (West) Schulz 13;
    B. Japonica Siebold 13;
    B. juncea (L) 13;
    B. pe-tsai 13;
    B. campestris L. 11.

11. CERCOSPORA BORINQUENSIS Young, Mycol. **8**:45. 1916.
    On *Calopogonium orthocarpum* Urb. 8, 13, 15; Herb. Univ. of Ill. **6752**; Stevenson **3186**.

*12. CERCOSPORA BRACHYPODA Speg. Anal. Soc. Cient. Argentina. **12**: 1881.

On *Abutilon hirtum* (Lam.) Sweet, collected by M. T. Cook, No data.

Abelmoschus esculentus (C) Moench. Herb. John A. Stevenson. No. 3565. Río Piedras.

13. CERCOSPORA BRADBURYAE Young, Mycol. **8**:46. 1916.

On *Bradburya pubences* (Benth.) Kuntze 8, 13 15; Herb. of F. L. Stevens **5785**; N. Y. Bot. Gard. **446, 3930, 5412, 6296**; Herb. Univ. of Ill. **225**a, **263**a, **446**a, **479, 5609, 5796, 6296, 6482, 6558**.

14. CERCOSPORA CAJANI P. Henn., Hedwigia **41**:309. 1902.

On *Cajan Cajan* (L) Millsp. 8, 11, 13, 15; **1179**; Herb. Univ. of Ill. **226, 294**a, **3556, 3798, 4832, 5100, 5608, 5733, 5874, 6029, 6058**a, **6752**.

*15. CERCOSPORA CALADI Cooke, Grevillea **8**: 95. 1879.

On *Caladium bicolor*. Herb. Exp. Sta. Río Piedras, P. R. **1189**.

*16. CERCOSPORA CALOTROPIDIS E. & E. Mo. Bot. Gard. Ann. Rept. **9**:120. 1898.

On *Calotropis procera* (Ait.) R. Br. **2739**.

17. CERCOSPORA CANESCENS Ell. & Mart., Am. Nat. **16**:1003. 1882.

On *Dolichos Lablab* L. 8, 11, 13; Stevenson **5130**.

Phaseolus vulgaris L. 7, 8, 11, 13; Herb. Univ. of Ill. **5722**.

Phaseolus lunatus L. 8, 11, 13.
Phaseolus lathyroides L. **1203, 2662**.
Vigna unguiculata (L) Walp. 8, 13.

18. CERCOSPORA CAPSICI Heald & Wolf, Mycol. **3**:15. 1911.

On *Capsicum annuum* L. 1, 8, 11, 13; **2982**; Stevenson **5049**.

19. CERCOSPORA CARBONACEA Miles, Trans. Illinois Acad. Sci. **10**:255. 1917.

On *Dioscorea alata* L. 7, 8, 13; Herb. of Univ. of Ill. **3563, 4178, 4187, 4234, 6469, 6687**.

20. CERCOSPORA CASEARIAE Stevens, Trans. Illinois Acad. Sci. 10:212. 1917.

On *Casearia* spp. 8; Herb. of Univ. of Ill. No. 99, 4190, 6115.

Casearia guianensis 9, 13; Herb. Univ. of Ill. **76, 99, 293**a, **311, 370, 387, 406, 420, 1386 3801, 3900, 3940, 4190, 4675 4691 4858, 4865, 5086, 5171, 5556, 5839, 6698, 7925, 8051, 9268, 9306, 9339**.

Casearia sylvestris Sw. 9, 13; **2973**; Herb. Univ. of Ill. **524, 3895, 5004, 5016, 5431, 5714, 7177, 7273, 7275, 7364, 7855, 7884, 8682**.

21. CERCOSPORA CITRULLINA Cooke, Grevillea, **12**:31. 1883.
.On *Citrullus vulgaris* Schrad. 8, 9, 10, 11, 13.

*22. CERCOSPORA CLITORIAE Atk. Jour. Elisha Mitchell Scien. Soc. **8**: 1892.
On *Clitoria ternatea* L. **2985**.

23. CERCOSPORA COFFEICOLA Berk. & Cooke. Grevillea **9**:99. 1881.
Cercospora coffeae—Zimm. Ber. u. Land. und. Fortstwirth Deutsch Ostafrick. **1904**:35.
On *Coffea arabica* L. 2, 3, 7, 8, 13; **498, 499, 3033, 3082**; Herb. of Univ. of Ill. **4827**.

24. CERCOSPORA CONSPICUA Earle, Bull. New York Bot. Gard. **3**:312. 1905.
On *Cleome* sp. 15; Herb. Univ. of Ill. **19, 6728**.
Cleome spinosa Jacq. 8, 13; **473**; Herb. Univ. of Ill. **7186, 8360, 8365, 8984, 9151**.
Cleome gynandra L. **1154, 1157, 1209**; Porto Rican Fungi (Heller) **6152**.

25. CERCOSPORA CRUENTA Sacc., Michelia **2**:149. 1880.
On *Phaseolus vulgaris* L. 11, 14
Phaseolus lunatus L. 8, 13; Herb. Univ. Ill. **222, 5989**.
Vigna unguiculata (L) Walp. 1, 8, 11, 13; *Stevenson* **6270**.

26. CERCOSPORA CUCURBITAE Ell. & Ev., Journ. Mycol. **4**:3. 1888.
On *Lagenaria leucantha* (L) Rusby, 8, 11, 13; Stevenson **5710**.

27. CERCOSPORA CUCURBITICOLA P. Henn., Hedwigia **43**:95. 1904.
On *Cayaponia* sp. 8, 9, 13.
Cuburbit Herb. Univ. of Ill. **3777, 4815**.

28. CERCOSPORA DENSISSIMA Speg., Anal. Mus. Nac. Buenos Aires Ser. **2, 3**:341. 1899.
On *Sida* sp. 8, 13, 15; Herb. Univ. of Ill. **6354, 6361**.

*29. CERCOSPORA ELEPHANTOPIS E. & E. Journ. Mycol. **3**: 15. 1887.
On *Elephantopus mollis* H. B. K. **1186**.

30. CERCOSPORA FLAGELLARIA Ell. & Mart., Am. Nat. **16**:1003. 1882.
On *Phytolacca icosandra* L. 8, 9, 13; Herb. Univ. of Ill. **2323**.

*31. CERCOSPORA FLAGELLIFERA Atk. Journ. Elisha Mitchell Scien. Soc. 8: 1892.
On *Galactia striata* (Jacq.) Urban. 1163.

NOTE: This specimen does not fit very well any of the Cercosporae described on this host or closely related hosts.

32. CERCOSPORA GILBERTII Speg., Anal. Soc. Cient. Argentina **10**:38. 1880.
On *Iresine panniculata* Kuntze 8, 9, 13; Herb. Univ. of Ill. **8286**.

33. CERCOSPORA GOSSYPINA Cooke, Grevillea **12**:31. 1883.
On *Gossypium barbadense* L. 1, 8, 13; **2975**.

34. CERCOSPORA GUANICENSIS Young, Mycologia **8**:45. 1916.
On *Caesalpina crista* L. 8, 13, 15; Herb. Univ. of Ill. **6843**; Col. of Agr. U. of P. R. **6840**.

*35. CERCOSPORA HELICTERIS Syd, Philippine Jour. Sci. (Botany) **9**:189. 1914.
On *Solanum torvum* Herb. Univ. of Ill. **361, 361**a, **486, 1144, 1266, 4691**.

NOTE: The specimens in these packets all look like the type material of *C. trichophila* Stevens on the same host. A detailed study, however, was not made to determine accurately their identity.

36. CERCOSPORA HEMIDIODIAE Toro Journ. Dept. Agric. Labor. Porto Rico, **14**. 1930.
On living leaves of *Hemidiodia ocimifolia* (Willd.), **1174**.

37. CERCOSPORA HENNINGSII Allesch., Engl. Ost. Pflanz. **3**:35. 1895.
Cercospora Cassavae Ell. & Ev., Bull. Torrey Bot. Club **22**:438. 1895.
On *Manihot utilissima Pohl.* 7, 8, 11, 13, 15, **462**; Herb. Univ. of Ill. **223, 254**.
Cassava sp. 9, 15; Herb. Univ. of Ill. **6557**.

A comparison of the descriptions indicate that C. *Henningsii* and

C. Cassavae are the same species. Stevenson (Journ. Dept. Agric. Porto Rico **2**:211. 1918) points out the similarity between the two.

38. CERCOSPORA HIBISCI Tracy & Earle, Bull. Torrey Bot. Club **22**:179. 1895.

On *Hibiscus tiliaceus* L. 8, 13, 15; Herb. Univ. of Ill. **8073, 8456, 8501, 8962, 9147, 9484**.

Abelmoschus esculentus (L) Moench. 7, 8, 11, 13, 14; Herb. Univ. of Ill. 310, 3630, 3793, 4797, 5030, 5229, 6465, 6618.

39. CERCOSPORA HURAE Stevens, Trans, Illinois Acad. Scie. **10**:210. 1917.

On *Hura crepitans* L. 8, 9, 13; Herb. Univ. of Ill. **70, 478, 3594, 5830**.

40. CERCOSPORA HYDROPIPERIS (Thuem) Speg. Anal. Soc. Cient. Argentina **9**:191. 1880.

Helminthosporium Hydropiperis Thuem, Mycotheca Universalis No. **1087**.

Cercospora Polygonorum Cooke, Hedwigia **17**:39. 1878.

On *Polygonum punctatum* Ellis. 8, 13; Herb. Univ. of Ill. **27, 69, 91, 419, 1154, 4578, 4586**.

*41. CERCOSPORA IPOMOEAE Wint, Hedwigia **26**: 34, 35. 1887.

On *Ipomoea* sp. **513**.

Ipomoea pes-caprae (L.) Roth. **514**.

42. **Cercospora Lantanae** Chupp. sp. nov.

On *Lantana camara* L.

Spots amphigenous, indefinite or on the upper surface of the leaf with minute brown center surrounded by a yellowish halo that merges with the green of the leaf. On the lower surface the spots are mostly indefinite or with a slight yellowing. When fruiting tufts are plentiful the spot has an olivaceous tinge. Conidiophores hypophyllous not in dense tufts, smoky to light brown slightly branched, 1–5 septate, sometimes constricted at the septa, 4–5 × 30–70 u. Conidia cylindrical, longer ones slightly attenuated, 1–3 septate, septation very evident sometimes constricted at the septa, smoky to light brown, 4–5 × 25–60 u. This seems distinct from any one of the large number of species described as being on the Verbenaceae.

Collected by C. E. Chardon (Collection No. 1200) at Peñuelas, July 21, 1920. A similar collection was made in Bermuda by Whetzel, March 15, 1922.

43. CERCOSPORA LEPIDII Peck. Ann. Rept. New York State Mus. **35**:140. 1884.

On *Lepidium* sp. 15;
Lepidium virginicum L. 8, 13.

44. CERCOSPORA LONGIPES Butler, Mem. Dept. Agric. India **1** (3) :44. 1906.

On *Saccharum officinarum* L. 6, 8, 14; Stevenson **6315**.

45. CERCOSPORA LONGISSIMA (Traverso) Sacc. Syll. Fung. **18**:607. 1906.

Cercospora longispora (Cug. in herb.) Traverso. Malpighia **17**:217. 1903.

Cercospora Lactucae Stevenson, Journ. Dept. Agric. Porto Rico. **1**:105. 1917.

Cercospora Lactucae Welles, Phytopath, **13**:289. 1923.

On *Lactuca sativa* L. 8, 11. Stevenson **5513**.

In Phytopathology **15**:247. 1925, Frank P. McWhorter calls attention to the fact that the name *Cercospora Lactucae* Stevenson invalidates *Cercospora Lactucae* Welles for reason of priority of name. He undoubtedly overlooked Saccardo's Sylloge Fungorum **18**:607, where *Cercospora Lactucae* P. Henn. is recorded. P. Hennings described his species in Botanische Jahrbucher **31**:742. 1902, and therefore his name has priority over *C. Lactucae* Stevenson and *C. Lactucae* Welles both of which are not tenable on this basis.

Traverso in Malpighia **17**: 217. 1903, describes another *Cercospora* on *Lactuca* and names it *C. longispora*. Saccardo, however, recorded this species as *C. longissima* since the name *longispora* was preoccupied by a species described by Peck. Traverso's description agrees in some points with those of Stevenson and Welles while it differs much from that of P. Hennings. As a result of his studies on the genus *Cercospora*, Welles states in Am. Journ. Bot. **13**:201, that "The measurements of the fruiting structures indicate decidedly that spore size as a means of classification is utterly valueless and misleading when spores are obtained from uncontrolled field lesions" and (p. 216) "that physiological behavior in relation to host range would give a more accurate and, perhaps, not an altogether clumsy method of arranging these parasites". In the light of our present knowledge of the taxonomy of these fungi one can only speculate on the validity of the above named species. From an examination of the literature one would appear to be forced to conclude that there are two distinct species of *Cercospora* on *Lactuca*: *C. Lactucae* P. Henn. and C.

longissima (Traverso) Sacc., with *C. Lactucae* Stevenson and *C. Lactucae* Welles, as probably synonyms of the latter.

46. Cercospora Malachrae Heald & Wolf, Mycologia **3**:19. 1911.
Cercospora Malachrae Young, Mycologia **8**:45. 1916.
On *Malachra alceifolia* Jacq. 8, 13, 15; Herb. Univ. of Ill. **338*a*, 381, 431, 5003, 5199, 5840**.

47. Cercospora maricaoensis Young, Mycologia **8**:44. 1916.
On *Teramnus uncinatus* (L) Sw. 8, 13, 15; Herb. Univ. of Ill. **2271, 5340, 5815, 6554**.

48. Cercospora mikaniacola Stevens, Trans. Illinois Acad. Sci. **10**: 213. 1917.
On *Mikania* sp. 8, 9, 13; Herb. of the Univ. of Ill. **4700, 5083, 7923** (*Type*).

49. Cercospora Nicotianae Ell. & Ev., Proc. Acad. Sci. Philadelphia **45**:170. 1893.
On *Nicotiana tabacum* L. 1, 7, 8, 9, 13; **2970**; Herb. Univ. of Ill. **23**; Stevenson **5336, 7060**.

50. Cercospora Oryzae Miyake. Journ. Coll. Agric. Tokyo **2**:263. 1910.
On *Oryza sativa* L. 8, 13.

*51. Cercospora papillosa Atk Journ. Elisha Mitchell Scien. Soc. **8**: 1892.
On *Valerianodes jamaicense* (L) Kuntze. **524**.

52. Cercospora personata (B. & C.) Ellis, Journ. Myc. **1**:63. 1885.
Cladosporium personatum B. & C., Grevillea, **3**:106. 1874.
On *Arachis hypogaea* L. 3, 8, 9, 11, 13, 14.

*53. Cercospora phaseolorum Cke. Grevillea **12**:30. 1883.
On *Phaseolus adenanthus* G. F. W. **538**.

Note: This specimen does not very well fit any of the descriptions of the nine species reported on Phaseolus.

54. **Cercospora phyllanthae** Chupp sp. nov.
On living foliage of *Phyllanthus Niruri* L.

Spots indefinite or none, marked only by the ashen gray coating of the fungous fruiting structures. Conidiophores mostly hypophyllous, sometimes amphigenous, dark brown, branched cylindrical, straight or slightly geniculate, in closely crowded fascicles of 3–12 conidiophores each, septate, 4 × 20–50 u. Conidia cylindrical,

nearly straight to slightly tortuous, base blunt and rounded, tip rounded to acute, 1–6 (mostly 2–3) septate, frequently constricted at the septum, hyaline 3–4 × 18–45 u.

Collected on Island of Vieques, July 18, 1924. *Type Whetzel Kern Toro* **2663** in Collection of Exploration of Porto Rico. Cornell University.

This *Cercospora* appears to be distinct from any of the other species recorded on members of the Euphorbiaceae. It is characterized by its relatively broad, branching conidiophores and broad conidia. Many of the conidiophores have a single side branch with a septum just above the point where the branch emerges.

55. CERCOSPORA PHYLLITIDIS Hume, Bull. Torrey Bot. Club. **27**:577. 1900.

On *Polypodium* sp. 8, 13, 15; Herb. Univ. of Ill. **121**.

56. CERCOSPORA PISA-SATIVAE Stevenson, Ann. Rept. Ins. Exp. Sta. Porto Rico **1917**–18:138. 1919.

On *Pisum sativum* L. 8, 11, 13; Stevenson **6777**.

57. CERCOSPORA PORTORICENSIS Earle, Muhlenbergia, **1**:15. 1901.

On *Piper* sp. **58, 92, 742, 3797, 3839, 3955, 4050, 4311, 4885, 4972, 4993, 5167, 5792, 6020.**

Piper aduncum L. 8, 9, 13; **463, 1150, 1181, 1190, 2680, 3124**;

Herb. Univ. of Ill. **22, 45a, 315, 412, 463, 1166, 7015, 7035, 7319, 7501, 7833, 8088, 8358, 8420, 8735, 9131, 9132, 9143, 9308, 9399**; Stevenson (**5804**);

Plants of Porto Rico No. **4359** (Earl), **4359, 6369** (Heller).

On *Piper Peltatum* L. 8, 13; **526, 1204, 7133**; (C. piperis Pat. Fungi Columbiana No. **4906**.)

Porto Rican Fungi (Heller) **6159, 6242**; Plants of Porto Rico (Underwood and Griggs, N. Y. Bot. Gard.) No numbers.

Piper Scabrum Sw. 8, 13, 15; **2240, 4792, 4802, 4804.**

Piper umbellatum L. 9, 13; N. J. Plant, Path., Herb. (Type material);

Herb. Univ. of Ill. **115, 146, 414, 417, 721, 7771, 7903, 8854.**

58. CERCOSPORA RICINELLA Sacc. & Berl., Atti. R. Inst. Ven. di. Sci. Let. Art. Ser. 6. **3**:721. 1885.

On *Ricinus* sp. **60, 84, 125, 3238, 6553.**
Ricinus communis L. 8, 9, 13; **1158, 1166, 1178, 1184.**
Herb. Univ. of Ill. **5973**; Stevenson **6354, 7050.**

59. CERCOSPORA RICOSPORA Atk., Journ. Elisha Mitchell Soc. **8**: 65. 1891.
On *Solanum nigrum* L. 8, 9, 13, **487, 1194, 2748, 3162.**

60. CERCOSPORA ROSAECOLA Pass., on Packet of the Thümen. Myc. Univ. No. **1086,** 1874.
On *Rosa* spp. 8, 13, 15; **1187**; Herb. Univ. of Ill. **737, 3447, 4806**; Stevenson **5841.**

61. CERCOSPORA SAGITTARIAE Ell. & Kellerm. Journ. Myc. **2**:1. 1886.
On *Sagittaria lancifolia* L. 8; **2670.**

62. CERCOSPORA SECHII Stevenson, Ann. Rept. Insular Exp. Sta. Dept. Agr. & Labor, Porto Rico, **1917**–18:137. 1919.
On *Sechium edule* (Jacq.) Sw. 8, 13; Stevenson **6888.**

63. CERCOSPORA SESAMI Zimm. Ber. u. Land—. Fortw. Deutsch–Ostafrica. **1904**: 28.
Sesamum sp. Stevenson **5836.**
Sesamum orientale L. 8, 11, 13.

64. CERCOSPORA SIMULATA Ell. & Ev., Journ. Myc. *1*:64. 1885.
Cercospora chamaecristae Ell. & Kellerm. Journ. Myc. **4**:7. 1888.
On *Cassia alata* L. 8, 13, 15; **537, 2749**; Porto Rican Fungi **6270.**
Cassia occidentalis L. 3, 8, 13, 15; **1165, 1197**; Herb. Univ. of Ill. **269**a, **3586, 3896, 6054, 7146, 7240, 7318, 7355, 7889, 8924, 9132.**

65. CERCOSPORA STEVENSII Young, Mycologia **8**:45. 1916.
On *Andira* sp. 15; Herb. Univ. of Ill. **6008, 6549**;
Andira inermis H.B.K. 8, 13.

*66. CERCOSPORA STIZOLOBII Sydow, Ann. Myc. **11**:270. 1913.
Cercospora Mucunae Sydow, Hedwigia **42**:106.
On *Mucuna* sp. Herb. Univ. of Ill. **3779, 6555.**
Mucuna pruritum (Wight) Piper 8, 13, 15; **479**; Herb. Univ. of Ill. **250, 3535, 3601, 3951, 4685, 4691, 4704, 4779, 4806, 4929, 6009, 7120, 8008.**
Mucuna urens (L) D. C. 8;
Stizolobium aterinum 13.

67. CERCOSPORA THOUINIAE Stevens, Trans. Illinois Acad. Sci. **10**: 213. 1917.
On *Thouinia striata* Radlk. 8, 9, 13. Herb. Univ. of Ill. **751**. Porto Rican Fungi, F. L. Stevens **751** (*Type*).

68. CERCOSPORA TIGLII P. Henn., Hedwigia **47**:265. 1908.
On *Croton lobatus* L. 8, **2657**.
NOTE: This fungus is new to Vieques Island.

69. CERCOSPORA TRICHOPHILA Stevens, Trans. Illinois Acad. Sci. **10**: 212. 1917.
On *Helicteres jamaicensis* Jacq. 8, 9, 13;
Solanum torvum Sw. 8, 9, 13; **484, 1154**; Herb. Univ. of Ill. **486, 3156, 7035, 7227, 7296, 7693, 7832, 7982, 8499, 9205, 9339**.
Solanum verbascifolium L. 8, 9, 13; **78260**.

70. CERCOSPORA TRICHOSTIGMAE Stevens, Trans. Illinois Acad. Sci. **10**:211. 1917.
On *Trichostigma octandra* (L) H. Walst. 8, 9, 13; Herb. Univ. of Ill. **9254, 9470**.

*71. CERCOSPORA TURNERAE E. & E. Mo. Bot. Gard. Ann. Rept. 9:119. 1898.
On *Turnera ulmifolia* L. **481**.

72. CERCOSPORA VAGINAE Krueger, Meded. Profest. West-Java **24**:8. 1896.
On *Saccharum officinarum* L. 1, 6, 8, 13, 15; Herb. Univ. of Ill. **7001**.

73. CERCOSPORA VENTURIOIDES Peck. Rept. State Mus. **34**:47. 1881.
On *Asclepias curassavica* L. 8; **1151, 2669**.

74. CERCOSPORA VIGNAE E. et. E. Journ. Mycol. **3**:19. 1887.
C. Vignae Racib. Zeitschr. Pflanzenkr. **8**:66. 1898.
(Probably a synonym as both have occasional branched conidiophores. The type material of both was not examined.)
On *Vigna repens* (L) Kuntze, **2744**.
Vigna unguiculata (L) Walp. 1, 8, 10, 11, 13.

75. CERCOSPSORA VIOLAE Sacc., Nuov. Giorn. Bot. Italia **3**:187. 1876.
On *Viola* sp. 8, 9, 13. **1149, 1160**.

76. **Cercospora Whetzelii** Chupp sp. nov.
On *Argemone mexicana* L.

Spots definite or sometimes indefinite, grayish brown to yellowish brown with darker margin on upper surface of leaf, brown to olivaceous with no margin brown, subcircular or when confluent irregular in shape, 2–6 mm. in diameter. Conidiophores amphigenous, in fascicles of 3–20, arising from stromae of varying sizes, fascicles gregarious, conidiophores light brown, irregularly cylindrical, straight to curved, sometimes geniculate, rarely if ever septate, 5–7 × 15–70 u. Conidia straight, cylindrical with rounded ends, sometimes slightly attenuated at one end, shorter ones unicellular, mostly one septate, rarely constricted at the septa, the point of attachment mostly very evident, 5–8 × 15–35 u. This seems different from any other Cercospora species described on the Papaveraceae.

Collected by C. E. Chardon at Ponce, Porto Rico, July 10, 1925. Chardon Collection No. **1161**.

DEPARTMENT OF PLANT PATHOLOGY
INSULAR EXPERIMENT STATION
RÍO PIEDRAS, PORTO RICO.

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NOTES ON BIRDS OBSERVED AT GUANICA LAGOON, AND ITS VICINITY

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During my residence at Santa Rita from November, 1924 to November, 1925 I availed myself of every opportunity to visit the lagoon. The lagoon presented a vast expanse of water which had collected during the few but unusually heavy rainfalls for this region. Although the lagoon has been up to four feet in depth at different times, it was very nearly dry during 1924 until the late rains of that year and 1925 raised the depth indicator to approximately three feet. Being almost of equal depth throughout, due to the fact that the lagoon's floor is perfectly level and very firm, added greatly to the pleasures of wading. I was told of large flocks of migrant ducks which were occasionally shot by employees of Guánica Central, but I never saw any. Observations on a number of birds that I observed follow.

1. *PODILYMBUS PODICEPS ANTILLARUM* Bangs. Antillean Grebe.

On February 1, 1925 I located a nest with one egg; by February 20 there were five eggs. March 9 as I approached the nest I glimpsed a parent bird peeping at me from among the pond grass. The nest, which it had just left, was a heaped-up mass of rotting vegetation raised four inches above the water's level, with a depression in the center. Examining the nest, I found only three eggs in it. Suspecting that the other two had hatched, I remained perfectly quiet, but had not long to wait until I heard the unmistakable "peep-peep-peep" of a young bird. Ascertaining the exact spot from which the sound came, I saw the little rascal as it propelled itself swiftly through the crystal water, using both legs together, after the fashion of frogs. The poor little chick tried its best to reach the opposite side where safety was assured, but the distance proved too great, and it bobbed up exactly as a large cork would, floating with only its head and rump above the surface, its legs spraddling out behind, and gasping for breath. I leaned over and was about to pick it up when, in spite of its exhausted condition, it again tipped forward and was heading for parts unknown, but it was unable to proceed for more than a foot. I picked it up, and its calls soon encouraged the second chick

to emerge from hiding. Holding both chicks in my hands, I forced them to utter their baby cries by tapping lightly against their breasts with my forefinger. I was about to turn them free when my efforts were repaid in a peculiar fashion. From somewhere among the pond grass a peculiar sound rent the stillness, followed instantly by a spray of water which went several feet into the air. The parent bird then stuck its head above the surface of the water within ten feet of me and gave another of its peculiar cries. Then ducking its head beneath the surface it tipped up, sending a shower of spray into the air with its feet and making a noisy splash with its wings. It continued these stunts for several minutes and finally disappeared. The call can be easily imitated, when once heard, by saying "Pluke" while attempting to whistle it at the same instant; a low note with plenty of volume. One chick was about two days older than the other, and when swimming on the surface of the water it used its legs alternately.

February 8, 1925 I found a nest and three young; a nest and two eggs, 1.69×1.13, and 1.33×1.13 inches; and a nest and five eggs, 1.56×1.19; 1.56×1.19; 1.50×1.19; 1.62×1.25, and 1.50×1.13; note the irregularities in the measurements of these eggs. The eggs vary from greenish blue to pale blue shells with a white chalky covering which is easily scratched particularly when the eggs are fresh. The eggs soon become nest-stained. On February 19 I found a nest and four eggs; the next day it contained five eggs, four of them nest-stained, and apparently the fourth had been deposited several days before the fifth, which was fresh and white in color with a bluish overcast. The nest was a floating mass of decaying grasses and algae gathered from the bottom; it measured 1 foot in diameter by 2 feet in depth, the highest part being only three and a half inches above the water level, with a concavity of about one inch in the center, and the eggs actually lying on the saturated bottom. On leaving the nest the parent bird always completely covered the eggs, oftimes with wet material hastily snatched from the side of the nest. One nest that I located contained three young birds. By the difference in their sizes the oldest chick must have been about two days older than the second.

2. ***ARDEA HERODIAS ADOXA*** **Oberholser. West Indian Great Blue Heron.**

The first time that I observed Great Blue Herons was on June 18, 1925. I had been out riding before dawn, and passing by the lagoon I saw, first, four of them sailing on set pinions as they came to rest

at the edge of the water. Having noticed that they had come from behind me I looked back and saw two more slowly winging their way towards the lagoon. When I rode away I counted nine birds scattered about the lagoon. All of them came from beyond the hills of the interior. I never observed any of them on the return flight, which was probably under cover of darkness.

3. *CASMERODIUS ALBUS EGRETTA* (Gmelin). Egret.

On March 14, 1925 I saw two Egrets. They were very shy and kept a considerable distance apart.

4. *BUTORIDES VIRESCENS MACULATUS* (Boddaert). West Indian Green Heron.

February 25, 1925 I searched the isolated trees near the lagoon for Green Heron nests and located two. Both of them were placed in tamarind trees, about twenty-five feet from the ground, and each contained two eggs.

5. *POECILONETTA BAHAMENSIS BAHAMENSIS* (Linné). Bahama Duck.

I never saw any ducks other than Bahama Ducks and a pair of Ruddy Ducks, which appeared, by their actions, to be nesting. During the month of December, 1924 I observed only four pairs of Bahama Ducks and they kept together. April 30, 1925 I received a female and two male Bahama Ducks which had been shot on a small fresh water pond overgrown with "rushes" lying near the coast on the outskirts of Ensenada.

6. *PORZANA FLAVIVENTER HENDERSONI* Bartsch. Yellow-bellied Rail.

In a patch of water plants on March 14, 1925 my attention was attracted by an unfamiliar sound. I froze in my tracks, and tried to associate it in my mind with others quite similar which I had heard. It was a single note, uttered once only, the first and last time I ever heard it. It was a softly whistled high pitched "peep" with a distinctly musical quality, entirely different from the familiar "peep" of the young grebe. Looking steadily in the direction from which the call came, almost at the same instant, I saw two Yellow-bellied Rails, one behind the other, scurrying across the broken and rotting vegetation, dodging behind leaves, and they were soon lost to sight. I raced after them, and no doubt would have forced them to seek safety by flight, but on reaching the spot where I had first seen them I found a nest with five eggs, and gave up the chase. The nest

was made of water grass neatly and compactly woven together, with no lining, and placed in the center of one of the water plants (*Pistia*), being held in place merely by the strength of the five upright green leaves, there being no visible evidence of any attempt to attach the nest. The nest measured 4.0 inches across the top by 5.25 in depth; the cavity 2.75 inches in diameter by 2.40 in depth, the lower end touching the water. Three of the eggs measured 1.09 × .82, and two of them 1.11 × .82 inches. They were uniform in shape, with one end slightly tapered. The ground color was glossy whitish cream, with large dark brown and blackish spots sparsely and evenly distributed over the shell, becoming fewer towards the smaller end. I marked the location of the nest, and on March 17 returned, but found the nest empty, apparently robbed, as the trampled "lanes" through the water grass remained as unmistakable evidence of the recent passage of nest-robbers.

7. *GALLINULA CHLOROPUS PORTORICENSIS* Danforth.
Antillean Gallinule.

On March 14, 1925 I found a Gallinule's nest with five eggs, the only nest of this species that I observed. It was in a patch of water plants. Three of the eggs measured 1.76 × 1.28 inches, and two of them 1.80 × 1.28 inches.

8. *FULICA CARIBAEA* Ridgway. Caribbean Coot.

Coots were very common on the lagoon. I estimated that there were at least 5,000 birds, and apparently they remained throughout the year. The first nest I found was on January 10, 1925. It contained two eggs, each 1.87 × 1.25 inches. A nest on January 30 contained one egg, 1.87 × 1.28. A nest on February 3 contained one egg 1.87 × 1.28 and three eggs 1.94 × 1.28. On February 5 a nest had two eggs 1.94 × 1.28. Note that although the eggs vary in length they all agree in their diameter. By February the breeding season was well advanced. One morning I counted sixteen nests within a radius of 100 feet, all of them completed and either ready to receive the eggs or else they had been robbed before the full complements were deposited. On February 21 I located six nests, all of them within a hundred yards from the lagoon's edge, made of grasses, and placed in beds of water grasses, the bottom of the nests being more or less level with the water. Nest and 5 eggs, 1.94 × 1.31; 1.87 × 1.31; 1.87 × 1.31; 2.0 × 1.31; 2.0 × 1.31. Nest and 7 eggs, 4 eggs 1.37 × 1.25; 3 eggs 1.44 × 1.25. Nest and 6 eggs, 3 eggs 1.87 × 1.25; 3 eggs 1.81 × 1.25. Nest and 4 eggs, 2 eggs 1.81 × 1.28; 2 eggs

1.75 × 1.28. Nest and 5 eggs, 2 eggs 1.94 × 1.31; 2 eggs 1.87 × 1.31; 1 egg 1.81 × 1.28; one egg is smaller in diameter. Nest and 6 eggs, 3 eggs 1.87 × 1.31; 2 eggs 1.81 × 1.31; 1 egg 1.75 × 1.31. It is interesting to note that all the eggs in a set have the same diameter measurements, excepting one set, while their lengths vary. I noticed in three instances that the eggs had been almost concealed with grasses, but also noticed that these nests were placed in broad patches of water grass and three or four feet from the open water, which leads me to believe that the parent birds involuntarily carried loose pieces of dead grass, attached to their long toes, into the nests, where they remained, apparently by the birds' indifference. On March 14 a diligent search revealed many nests, but not one with even a single egg.

9. *PAGOLLA WILSONIA WILSONIA* (Ord). Wilson's Plover.

May 16, 1925 I found the nest of a Wilson's Plover with three eggs. The following day they were hatched, and the three chicks running about. This nest was near the lagoon on a bank of earth, and the parents were the only birds of this species observed in the vicinity.

10. *OXYECHUS VOCIFERUS RUBIDUS* Riley. West Indian Killdeer.

On June 10, 1925 I saw a pair of Killdeers followed by three newly hatched chicks. They kept to the open pasture, and far from the lagoon.

11. *HIMANTOPUS MEXICANUS* (Müller). Black-necked Stilt.

May 14, 1925 I found the nests of four pairs of Black-necked Stilts with four eggs in each, at the edge of a small fresh water pond near the Bay of Guánica. The nests were made of short pieces of coarse sticks placed in depressions among the short grass. May 17 I found a nest with four eggs about 400 yards from the lagoon. On the 26th I found three chicks and one egg in the nest, and both parent birds in attendance. The following morning I found the four chicks hiding in the grass and both parent birds were frantic in their efforts to keep me from the vicinity. That afternoon I again passed the locality, and to my great surprise, the Stilts were nowhere to be seen. The site was an open pasture, studded here and there with small clumps of cactus; it was impossible for them to remain here without being seen. I gave considerable thought to their disappearance, and came to the conclusion that the chicks had either been devoured by a roaming mongoose or that the parent birds had led them

off toward the water. Early the following morning I rode by the lagoon, and sure enough, there was one of the adults making a great deal of noise. Dismounting, I commenced to search among the tufts of grass with high hopes of finding a chick. After searching for about two minutes I stepped into a clearing, bare of grass and broken up with the tracks of cattle, and scanned the air for the other adult Stilt, but it was nowhere in sight. Taking a step with the intention of continuing the search, what should I find but a chick flattened against the ground, and lying in the mark of a track, at the point of my boot. A Stilt appeared in the distance, coming from the site of her nest and flying low over the tall grass. I watched her as slowly she winged her way towards me, where I was squatting, and presently passing on my right I noticed a dark object hanging limply from her bill. As she alighted about twenty yards from me, I ran swiftly towards her, taking advantage of the clusters of reeds to hide my approach, and bursting suddenly upon her she flew up, very much frightened, while a little chick, too scared even to move, remained flattened against the ground. I took it up and set it down again, and off it ran, twisting about so swiftly that I made several futile attempts to recapture it before I was successful. The parent Stilt had brought her chick to the water by taking hold of it by the neck, its head protruding from her bill on one side, while its little body dangled from the other.

12. *CHLOROSTILBON MAUGAEUS* (Audebert and Vieillot). Porto Rican Emerald Hummingbird.

March 9, 1925 I located a nest of this hummer containing a single pure white egg, 0.50 × 0.33 inches; the nest was made of wild cotton, and was 1.5 inches in diameter by 2.0 in depth, the cavity being .85 inch in depth by .75 in diameter. It was placed about five feet above the ground on the slender waving branch of a large tree. The female left the nest eight times during one half hour for short periods, making excursions among the barrel cacti, gleaning spiders from their webs among the spiny cacti, and nectar from their blossoms. On March 16 a newly hatched young was in the nest. Upon my approach the female came towards me, remaining suspended before my face on blurred pinions. I made a quick grab at her, but my speed was like slow motion in comparison with hers as with a buzz she was off. Standing motionless with my face a foot from the nest, she suddenly appeared, and hanging in the air, two feet away, looked at me suspiciously for a moment, then rising slowly for several inches, she advanced with a sharp buzz, checked herself, and deliberately

started to fly backwards and slightly downwards, still facing me. With another buzz she alighted on the nest with her breast towards me. Then she began acting as though very sleepy, but proved to be very much awake when I attempted to touch her on the crown. I noticed that every time she settled on the nest to incubate it was done without first alighting on the rim, and that when leaving she flew off either upward or directly forward. Several times she fed the chick while suspended in the air on blurred pinions, stretching her neck downward and placing her bill into the throat of the little fellow as she regurgitated a mass of predigested insects and nectar. On April 7, after a period of 23 days, the chick left the nest.

April 5 a nest, with a single egg, made of wild cotton, and placed fifteen feet above the ground on the slender branch of a "Roma" was found.

March 1 I found an incomplete nest of this hummer attached to a slender branch of a mango tree four feet above the surface of a stream.

13. *TODUS MEXICANUS* Lesson. Porto Rican Tody.

Todies were common along the dry *arroyo* which passed by Santa Rita and emptied into the lagoon. In some places the rushing waters had cut their way through the gravelly clay soil leaving the banks from five to ten feet in height, with a fringe of trees and heavy undergrowth along the edge. Here the Todies delighted in darting about catching insects on the wing with marvellous swiftness, seldom ever missing. One day while following the *arroyo* in its windings, riding over the dry bed, I entered a secluded spot where the banks were perpendicular and large trees extended their branches across the top. Here I was greeted by the single call note of a Tody; it sounded like "*psoop*", and was generally repeated from five to ten times. A good imitation may be obtained by whistling it while the tongue is held against the roof of the mouth and the lips moved as though trying to speak the word at the same time. There, perched on a very long and slender sapling, not five feet from me, was a little ball of feathers, all puffed up, with dreamy eyes, and every time it uttered a note it would rise up on its feet as though by the effort. Cocking its head to one side with its bill pointing upward it would close first one eye, then the other. Every now and then its wings would open and close so swiftly that the motion was scarcely perceptible. Several tiny insects were quickly caught as, with a whirring sound, it launched out into the air and returned to its favorite perch. Apparently the whirring sound is produced by the primaries, and the

distinctly audible whistling sound, produced at the same instant as the whirring, is caused by the passage of air through the primaries. These sounds are produced only during flight, by the will of the bird, and by both sexes. While the little actor was amusing itself a second bird, presumably its mate, alighted beside it, and calling continuously for fully one minute, she suddenly dived, head downward, and disappeared into the side of the bank. I have seen several wonderful stunts performed by the feathered folk, and this one by a Tody easily takes its place among them. The bank had a smooth perpendicular face, the Tody was sitting a foot and a half from it, while four feet below her was the nesting hole with its two-inch entrance. One should really be acquainted with the little bird and the size of the entrance to its home in order to fully appreciate the wonderful control and keen sight exhibited when she dived and disappeared into the hole without disturbing even a tiny pebble at the entrance, bearing in mind that her passage through the air appeared as a green streak and without any hesitation at the entrance.

14. *TOLMARCHUS TAYLORI* (Sclater). Porto Rican Petchary.

February 25, 1925 I located a Petchary's nest, constructed of coarse sticks, neatly lined with horsehair and fine rootlets, deeply cupped, and placed at a fork on a horizontal branch of a Roma thirteen feet above the ground. It contained one egg which was rich salmon white spotted with large brown and chocolate spots and scrawls, heavier about the larger end. The nest measured 7 inches in diameter by 2.5 in depth. The cavity was 3 inches in diameter by 1.75 in depth. On March 1 it contained three eggs, similar in color and markings. March 20 there were two young and one egg. On the 21st there were three chicks in the nest, and the parent birds were very noisy and aggressive. Only insects were fed to the nestlings, and the task of supplying the demand was shared equally by the adults.

15. *BLACICUS BLANCOI* Cabanis. Porto Rican Pewee.

April 4, 1925 I made an excursion in the wild brushy country between Santa Rita and the south coast. At noon I stretched myself out under a tree to rest, and observed a male Pewee catching insects. From somewhere, the female appeared and alighted on a branch directly above my head. The male, having seen her as she came, flew up, and almost at the same instant alighted beside her. Then followed an exchange of very softly uttered notes, "*whup, whup, whup*", so soft that they were scarcely audible. Slowly and quietly I shifted

my position, and looking up I saw the female sitting on her nest, lengthwise with the branch. My first thought was how to reach the nest. A peculiar thing about a Turpentine tree is the way the thin outer skin peels and blisters but remains attached, which makes climbing difficult without the use of climbing irons. I found a way, however, by coaxing and pushing my little horse over the rocks until he was in a position that permitted me to grasp the lowest horizontal branch, by means of which I pulled myself up. The nest was placed on this same branch, about 14 feet from the ground and 6 feet from the trunk, but the brittleness of the wood made me doubt whether I should attempt to reach it. I finally decided to take the risk, and edged slowly, as smoothly as possible, forward until I could bend over and touch the nest. I measured the single egg, .75 × .55 inch, white with a pinkish tint, marked sparingly about the larger end with lilac and brown spots and lines. The nest measured 2.5 inches in diameter by 1.75 in depth, the cavity 1.80 in diameter by .75 in depth. It was composed entirely of green moss compactly woven together and completely covered on the outside with bits of "skin" taken from the turpentine tree, which camouflaged the nest so perfectly that it was absolutely impossible to detect it from below unless the parent bird was sitting. During the four or five minutes that I was busy taking the measurements the parent birds remained silent but kept close by, sometimes coming within three feet of me, twisting their heads from side to side with the crown feathers rising and falling as their beady little eyes followed my every movement. At the conclusion I froze on my precarious perch and whistled an imitation of their call note, at which they became very much excited, flitting from branch to branch with tails nervously twitching, and quite unexpectedly one of them flew to the nest and covered the single egg, two feet from my face, leaving only when my finger was about to touch its back.

16. *MIMUS POLYGLOTTOS ORPHEUS* (Linné). Jamaican Mockingbird.

I observed the first Mockingbird's nest on January 28, 1925 and the last one on April 16. During this period the birds were very active, the males fighting among themselves and reeking vengeance on all unsuspecting feathered folk who ventured too near their nesting sites. The females were as vicious as the males in the defense of their nests and young. Of fifteen nests which I observed in an isolated area, about 600 by 300 feet, planted to a species of acacia locally called "Roma", fourteen contained three eggs, and one four eggs.

I was particularly impressed by the constancy of coloration and uniformity in shapes and sizes of the eggs. Every pair of nesting birds were matured adults and not birds of the year. There were never more than seven or eight pairs of birds in the immediate vicinity of the "Romas", which, with the similarity in eggs and nests, makes me believe that a few pairs raised two broods, and perhaps even three, in the season. The average measurement of 21 sets of eggs, consisting of 19 sets of three eggs each, and 2 sets of four eggs each, was $1.02 \times .73$ inches. A nest measured 10.0 inches in diameter by 4.0 in depth, the cavity being 3.0 in diameter by 2.75 in depth; it was composed of coarse sticks of "Roma", lined with horsehair and a few feathers. Young birds were fed caterpillars, small grasshoppers, and crickets, by both parents.

17. *VIREO LATIMERI* Baird. Latimer's Vireo.

May 18, 1925 I saw a female Latimer's Vireo completing a nest of soft grass blades while the male sang nearby. The nest was similar to that of the Jamaican Vireo, hanging from a forked branch ten feet from the ground.

18. *VIREO OLIVACEUS OLIVACEUS* (Linné). Jamaican Vireo.

I was particularly impressed by the difference between the songs of the vireos found on Porto Rico and those on St. Croix. Accustomed as I had become to the song of the St. Croix bird from hearing it many years, I was startled by the many variations in the song of the Porto Rican bird from the first time that I heard it, though their habits are identical. The song is a steady outpouring by the males from dawn until midday, becoming less frequent as the afternoon advances. I shall attempt to record five distinct song notes in writing as follows:

(1) Cheop chee / weee ; (2) Cheop pee arr / weee

(3) Cheop / chee up ; (4) Cheo / chea ; and

(5) Cheop / pe wee . The song notes are delivered with a full, forceful warble, attractive and pleasing. It was during the very early morning of March 3, 1925 that I heard the first song and saw the first bird for the year. The bird was in the leafy top of a turpentine tree. One moment it was on the top of a bunch of berries, the next it was hanging head downward at the bottom, carefully choosing the very ripest berries and swallowing them whole. The

fleshy red skins of these berries are easily separated, during the process of digestion, from the hard indigestible stones, which are soon afterwards ejected through the mouth. May 17, 1925 I observed a nest hanging from the extremity of a long slender branch. The female was incubating while the male sang nearby. The nest was about twenty-five feet from the ground. I saw no birds after August 15.

19. *COEREBA PORTORICENSIS PORTORICENSIS* (Bryant).
Porto Rican Honey Creeper.

Honey Creepers were not so numerous about Santa Rita as they were among the fruit gardens further inland, where they were always heard singing lustily as they chased each other, stopping here and there to take a few pecks at a ripe mango. Or a male scolds passionately as he dashes after a female, and they are off, headed for the nearest wild cotton shrub, from which presently they may be seen returning, each with a tuft of cotton in its bill for the nest snugly hidden amongst a cluster of long green leaves at the end of a slender branch of a mango tree. During February and March I found several nests. One that I found on March 3 was about 30 feet up, an unusual height, at the end of a thin branch of a mango tree.

20. *DENDROICA PETECHIA CRUCIANA* Sundevall. Porto Rican Golden Warbler.

May 11, 1925 I found a nest of a Golden Warbler with three young. The nest was placed between the forked branches of an "acacia" bush that grew on the bank of the lagoon, two feet from the water's edge, situated two and a half feet from the ground. Both parents were kept busy searching for fat worms and tender bugs to satisfy the hungry little stomachs.

21. *DENDROICA ADELAIDAE* Baird. Adelaide's Warbler.

April 14, 1925 while riding through the grove of "Romas" I saw an Adelaide's Warbler with a tuft of cotton held in her bill. Reining in my pacer, I watched her as she flew to the nesting site. Waiting until she had gone in search of more material, I went to the spot and found an incomplete nest. On the 21st I examined the nest and found it empty with the pieces of two broken eggs on the ground beneath. The nest was made of cotton and soft grasses lined with horse hair and feathers, placed six feet up in the crotch of a three-forked slender upright branch.

April 27, 1925 I visited an area near Limón which was overgrown with several species of cactus and thorny shrubbery. Here and there

the barrel cacti supported masses of climbing prickly vines. Riding by one of these clumps, the thorns caught in my shirtsleeve, and the resulting commotion scared an Adelaide's Warbler from her nest. The nest was six feet from the ground, and well concealed from view on all sides. It was made of dry grasses lined with hairs, back feathers of a Mockingbird, and soft, fine dry seedstalks of grasses, resembling the nest of the Golden Warbler. It measured 2.10 inches in diameter by 2.0 in depth, the cavity being 1.5 in diameter by 1.4 in depth. The three eggs were white with a greenish tint, wreathed around the larger end with fine chocolate spots, the rest of the shell being sparingly spotted with brown. The eggs measured $.64 \times .48$; $.64 \times .48$, and $.63 \times .48$. During the time that I was busy at the nest the parent bird kept among the dense growth, occasionally showing herself as she seemed to glide about with little effort, calling a loud sharp "*chip*", similar to that of the Golden Warbler. I heard the song of several males, which is very pleasing and rich.

22. *HOLOQUISCALUS NIGER BRACHYPTERUS* (Cassin).
Porto Rican Grackle.

On March 7, 1925 a nest I had observed being built contained one egg, on the 10th there were two eggs, and on the 17th three eggs; this does not mean that the third egg was deposited on the 17th; I did not find the time to visit the nest between the 10th and 17th. On the 22nd the eggs were still unhatched. The nest was built in a crotch near the trunk of a "pine". The female would fly to a water hole or a drain to collect straw or other rotting vegetation covered with soft mud, and return to the nesting site with the material in her bill. Meanwhile, the male was never far away at any time, even in the air he could be seen trailing along not more than three feet behind her. He was a persistent love maker, and evidently knew that unless he kept an eye on his spouse she was likely to fall for a more ardent suitor, of which there were always a few around awaiting the chance. One habit she had that was very annoying to him was that she would fly up unexpectedly from the feeding ground, and proceeding for a couple of hundred of feet into the air, carried along by a series of slow, deliberate wing beats, she would describe a wide circle only to return and continue the interrupted meal. Meanwhile, the male, trailing behind her, went through a comic performance of short, rapid wingbeats, sailing for a short distance, pouring forth an unbroken medley of passionate songs. Then, after alighting, he proceeded to scold and strut around stiff-legged, tossing his head backwards one

moment, or pressing his bill against his breast the next, crying passionately oooo / wip ee \ arrrr, a whistled sound which must be inhaled to obtain the desired effect. The female did not pay the slightest heed to any of his acting, merely accepting all the love croonings and passionate outbursts showered on her by her chosen lord, as proof of his fidelity. The construction of the nest was undertaken by the female alone, while both sexes shared in the incubation.

April 23, 1925 I found two nests located in a "Roma" about eight feet from the ground. One nest contained three eggs with a bluish green ground color, splotched and scrawled with umber and chocolate brown. The other nest was empty.

The same day (April 23) while crossing Hacienda "Limón" my attention was attracted by a flock of Grackles noisily announcing themselves from a large isolated clump of cactus. Veering off from the cowpath, I soon arrived at the spot where bedlam broke loose, and a hundred birds fluttered about me. The cluster of cactus was, more or less, 30 feet long by 12 wide and 10 high, and thickly matted together. Everywhere that I looked, from the top to near the ground, and for all the length and breadth of this patch, there were nests in all stages of construction, and six containing four eggs apiece. In all there must have been about thirty nests. One interesting thing I noticed was that a nest which contained four fresh eggs also contained a large amount of excrement from nestlings, a sign of its previous occupancy. It was impossible to determine, however, whether the same pair of adults were raising a second brood or if a strange pair had found the nest suitable to its needs.

23. ***TIARIS BICOLOR OMISSA*** **Jardine. Carib Grassquit.**

March 4, 1925 several Grassquit nests were being constructed. March 16 a nest was started and on April 2 it contained two eggs. A nest with one egg April 12 only contained two eggs when I examined it on the 15th; I am sure this nest was deserted. April 28 I found another nest with one egg. This was placed one foot from the ground in the crotch of a barrel cactus. Many other nests were placed among cacti, acacias, and in several instances among the trash at the bases of bunches of sugar cane.

24. ***LOXIGILLA PORTORICENSIS*** **(Daudin). Porto Rican Grosbeak.**

On May 18, 1925 I watched a pair of Grosbeaks constructing their nest, which was situated in a cluster of thorny vines, five feet from

the ground. The incomplete nest was domed, with the opening at the side, similar to the nest of the Carib Grassquit, only larger, being about seven inches in diameter. One adult bird gathered the nest material, while the other followed close behind uttering a variety of call notes.

PUERTO RICAN ORNITHOLOGICAL RECORDS

By Stuart T. Danforth
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In 1926 I published in the Journal of the Department of Agriculture of Porto Rico a paper entitled "Birds of the Cartagena Lagoon, Porto Rico". This paper included my observations until 1924 on the birds of the lagoon referred to, also such other notes as I had from other parts of the island concerning species which were also found at the lagoon. The present paper is intended to be complementary to the Cartagena Lagoon paper. It includes such information as I have obtained since 1924 regarding the birds discussed in the previous paper, and in addition any information that I have concerning those species which were not mentioned in that paper. I have endeavoured as far as possible not to repeat any information previously published. However, for the sake of completeness, I have listed all the birds that I have observed in the island. In the few cases where I have not obtained any additional information on a species, I simply refer to the previous paper. Also, in order to make a more inclusive summary of migration dates, all the migration dates that I have are listed. With these small exceptions, no information has been repeated.

The information included in this paper is based upon the following periods of time which the author has spent observing birds in Porto Rico, during which he has visited every town on the island: From October 1921 to June 1922; November 1923 to October 1924; and from September 1926 to the present writing in 1930, with the exception of two or three months during each summer, and occasional shorter periods in the Christmas vacations when other islands were visited.

In company with a number of his students the writer spent three days (May 7–9, 1927) on Desecheo Island. The observations made on that trip are also recorded in this paper.

The accompanying map shows only those localities at which I have collected or observed birds. Practically every locality to which reference is made in the paper which follows will be found upon this map.

Under each species I have attempted to give the English and Spanish names in actual use, followed by such notes as I have ob-

tained on habits, nesting, food, and migration; also a list of the localities in Porto Rico at which I have observed each species, and a catalogue of the examples of each from Porto Rico which I now have in my collection. This collection is at present deposited at the College of Agriculture of the University of Porto Rico at Mayagüez. The catalogue does not include those specimens which I have collected but which are now in other collections. Most of the specimens to which reference is made in my former paper are now in the collection of Cornell University. A few specimens collected since then have been sent to some four or five other institutions.

The writer wishes to express his thanks to Mr. John T. Emlen, Jr., of Philadelphia, for permission to reproduce a few of the photographs which he took during a short visit to the island.

1. *COLYMBUS DOMINICUS DOMINICUS* (Linné).
Least Grebe. Tigua.

Least Grebes are common birds on the larger fresh water lagoons of the island, and are found occasionally on some of the reservoirs. I have found them regularly at Cartagena, Anegado and Guánica Lagoons. On March 24, 1929 I observed eight at the Coamo Springs Reservoir, and on November 30, 1929 one at the Guayabal Reservoir.

At Anegado Lagoon on September 29, 1926 I observed a pair of Least Grebes accompanied by five downy young, which were riding on the back of one of the parents. The parent with the young on its back hid for half an hour behind a pond lily leaf which was blown into a vertical position by the wind. After observing them for some time I walked slowly towards them. The parent suddenly dove and the young scattered swimming in all directions under water. I succeeded in catching one of them as it came up for air. The young birds uttered faint whistling peeps.

Porto Rican specimens now in my collection:
No. 1, male, Cartagena Lagoon, Sep. 9, 1924.
No. 2, female, Cartagena Lagoon, Sep. 17, 1924.
No. 3, downy young, Anegado Lagoon, Sep. 29, 1926.

2. *PODILYMBUS PODICEPS ANTILLARUM* Bangs.
Antillean Pied-billed Grebe. Zaramago.

This grebe is much more generally distributed in Porto Rico than the Least Grebe, being found in some of the larger river marshes as well as in the fresh water lagoons. I have found it common at Cartagena Lagoon, Anegado Lagoon, Guánica Lagoon, the Isabela

Irrigation Reservoir, and the Guayabal Reservoir. When the Coamo Springs Reservoir is full I have observed as many as fifty there, and whenever there is any water at least a few may be found. On December 29, 1929 I saw one in the river marshes at Arecibo, and on March 7, 1927 a pair on the brackish water Laguna Tortuguera.

The stomach of an example collected at Cartagena Lagoon was almost completely filled with feathers. The only food that it contained was a few fragments of creeping water bugs (*Pelocoris femoratus*), which amounted to only 3 per cent of the stomach contents.

Porto Rican specimen now in my collection:
No. 669, female, Cartagena Lagoon, Nov. 18, 1928.

3. *OCEANITES OCEANICUS* (Kuhl). Wilson's Petrel.

The Wilson's Petrel undoubtedly occurs frequently offshore during the summer, but it does not seem to have been definitely known from Porto Rico until I recorded (Bulletin of the Northeastern Bird Banding Association, Vol. 3, 1927, p. 59) an example seen two miles west of Rincón Point on May 9, 1927. More recently, on a trip from San Juan to New York, Wilson's Petrels began following the steamer when we were about fifteen miles north of San Juan. This was on May 23, 1928.

4. ***PHAETHON LEPTURUS CATESBYI*** **Brandt. Yellow-billed Tropic Bird. Caracolera. Gaviota de Rabo Largo.**

About a dozen pairs of these birds (known locally as Caracoleras) nest every year at some precipitous limestone cliffs east of the mouth of the Guajataca River between Isabela and Quebradillas. Near this locality a number of individuals can be seen any day during the breeding season, which is apparently from April to July. On one occasion I was shown a large dome-shaped cave the roof of which had fallen in. There were little niches in the walls of the dome in which I was told the birds nest, but at that time it was too early in the season for any birds to be nesting. The earliest date at which I have observed the species at this locality is March 9, 1930, although I am told by people residing in the region that they arrive by the middle of February.

On March 22, 1929 I observed a pair circling around over the water near Tallaboa, on the south coast. Suddenly one flew into a hole in an inaccessible position in a high cliff near the shore, from which it could not be persuaded to emerge even upon firing a shot in close proximity to the hole.

5. *PELECANUS OCCIDENTALIS OCCIDENTALIS* Linné.
Brown Pelican. Alcatraz.

The Brown Pelican is a very common bird along the coasts of Porto Rico at all times of the year. I have never found it breeding on the main island, but it is a fairly common breeder on small islets off the coast. About forty pairs nest on Cayo Enrique, a small mangrove island near Parguera. On April 2, 1927 forty nests were found in the tops of the mangroves from eighteen to twenty feet above the ground. At that time each nest contained two enormous dirty white eggs. Apparently the nesting season is not very regular, since on a visit to the same colony on March 22, 1928 I found that most of the nests had young ranging in size from newly hatched birds to those nearly ready to fly. Also one nest with two much soiled eggs nearly ready to hatch, and another with one fresh white unincubated egg were found on this date. The young Pelicans in the nests thrust their bills viciously at intruders, but they were incapable of inflicting much injury. On August 15, 1927 Mr. John T. Emlen, Jr., and the author visited the same colony. On this occasion we found that most of the nests contained well grown young, but a few nests with smaller young and one with three eggs were found. Many immature birds with white heads were flying around, and they frequently alighted on the mangroves beside the nests.

Brown Pelicans are almost never found at fresh water, but on March 23, 1929 I noted one perched in the marsh at the edge of the open water on the Coamo Springs Reservoir.

Localities at which I have observed Pelicans are: Aguadilla, Aguada, Rincón, Añasco, Mayagüez, Joyuda, Rat Island, Puerto Real, Boquerón, Faro de Cabo Rojo, Parguera, Cayo Enrique, Ensenada, Guayanilla, Tallaboa, Ponce, Pastillo, Coamo Springs Reservoir, Salinas, Playa de Naguabo, Fajardo, Mameyes, Río Piedras, San Juan, Hatillo, Arecibo and Quebradillas.

6. *SULA LEUCOGASTRA LEUCOGASTRA* (Boddaert).
Common Booby. Pájaro Bobo.

The Booby is a common bird off the coasts of Porto Rico, usually keeping offshore, but occasionally perching on rocks along the coast.

From May 7 to 9, 1927 I visited the breeding colony of this species on Desecheo Island. At that time it was decidedly the most abundant bird on the island. It was very difficult to count them, but I believe fifteen thousand birds to be a safe estimate. At the time of my visit the nests contained young in all stages of develop-

ment. Most of them had passed the downy stage, and no eggs were found. The birds were nesting all over the island from the seabeach to the top of the highest mountain, but most abundantly within two hundred feet of the shore. Young birds which were nearly full sized, but could not yet fly, would bite viciously at persons walking near them. A fisherman who accompanied our little expedition would on such occasions give the offending bird a kick into the cactus or other nearby brush. Large numbers of adults were fishing a short distance offshore, where they were being continually harassed and robbed by Man-o-war Birds. When passing by Desecheo in a boat on August 10, 1927 I observed many fishing near the island.

On the main island of Porto Rico I hâve observed Boobies at Point Borinquen, Aguadilla, Aguada, Rincón, Mayagüez, Joyudà. Puerto Real, Faro de Cabo Rojo, Fajardo, and Hatillo.

Porto Rican specimens now in my collection:

No. 399, female, downy young, Desecheo, April 21, 1927.
No. 400, female, adult, Desecheo, May 7, 1927.
No. 715, Immature, Mayagüez, Feb. 15, 1929.

7. *SULA PISCATOR* (Linné). Red-footed Booby. Pájaro Bobo.

The Red-footed Booby is scarce off the coasts of Porto Rico, but there is a small breeding colony on Desecheo Island.

On August 10, 1927 I observed five adults and ten brown young with white tails feeding a short distance off Point Borinquen, the northwest corner of Porto Rico. On December 2, 1929 I observed an adult diving for fish about half a mile offshore at Joyuda.

From May 7 to 9, 1927 I made observations of the breeding colony on Desecheo Island. All the birds of this species, (about fifty pairs) bred in a small area about a hundred and fifty feet back from the southern shore of the island. Their nests were placed in a growth of *Elathrium* and other shrubby trees surrounded by an almost impenetrable growth of *Opuntia* cactus. Birds in the fully adult black and white plumage were scarce, and many birds in the brown plumage with white tails were caring for young. Most of the young were in juvenile plumage, though a few still in their natal down could be observed. The smallest of these were from sixteen to eighteen inches in length. The nests were rather crude affairs of sticks placed at heights of from four to twelve feet in the shrubs. The adults, especially those in the fully adult plumage, were much more wary than the Common Boobies. When our party returned to Mayagüez I brought back with me one of the smallest of the downy young, and

kept it as a laboratory pet for nearly two weeks. It fed greedily upon fish obtained in the market.

Porto Rican specimens now in my collection:
No. 401, male, adult plumage, Desecheo, May 7, 1927.
No. 402, male, immature plumage, Desecheo, May 7, 1927.
No. 409, female, downy young, Desecheo, May 20, 1927.

8. *PHALACROCORAX OLIVACEUS MEXICANUS* (Brandt).
Mexican Cormorant.

My only record of a Cormorant from Porto Rico is that of a bird probably of this species observed at Cartagena Lagoon on October 17, 1924, and previously recorded in my "Birds of the Cartagena Lagoon".

9. *FREGATA MAGNIFICENS* Mathews. Man-o-war Bird. Rabijunco. Tijerilla. Anunciador.

The Man-o-war Bird is a frequent visitor to all parts of the coast of Porto Rico at all times of the year. It breeds on Desecheo, Cayo Enrique, and possibly some of the other islets off the coast of Porto Rico.

A colony of at least sixty pairs nests on Cayo Enrique. These birds and the Little Blue Herons and Snowy Egrets nest on one end of the key, and the Pelicans and Black-crowned Night Heron's on the other end. The nests of the Man-o-war Birds are placed on the mangroves at heights of from eight to twelve feet. On April 2, 1927 these nests contained one young apiece, ranging in size from newly hatched birds to those nearly ready to leave the nest. One nest still contained an egg, and one nest contained two fairly large young. The adults on their nests permitted me to approach within three or four feet of them before taking flight. On March 22, 1928 about the same conditions were found to be true, but no eggs at all were seen. On August 15, 1927 this colony contained many nests with good-sized young, mostly still in their natal down, but a few in juvenile plumage learning to fly were noted. On this visit no eggs nor small young were seen.

During my stay on Desecheo Island from May 7 to 9, 1927 I found two nesting colonies of Man-o-war Birds in scrubby trees in the lower hills in the interior of the island. The total number of nests in the two colonies was about a hundred and twenty-five. They contained young in various stages of development. Fifteen years before Dr. Wetmore had noted a nesting colony on the highest hill, but

there was none there at the time of my visit. Large numbers of Man-o-war Birds were robbing the Boobies which were feeding off the coast of Desecheo.

On the main island of Porto Rico the Man-o-war Bird is found mostly along the coast, but occasionally visits fresh water lakes in quest of fish. I have recorded the species at the following localities in Porto Rico: Point Borinquen, Aguada, Rincón, Añasco, Mayagüez, Joyuda, Puerto Real, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Parguera, Cayo Enrique, Ensenada, Ponce, Coamo Springs Reservoir, Humacao, Río Piedras, San Juan, Laguna Tortuguera, and Quebradillas.

A stomach from Cayo Enrique contained only fish remains.

Porto Rican specimen now in my collection:
No. 377, female, Cayo Enrique, April 2, 1927.

10. *ARDEA HERODIAS ADOXA* Oberholser. West Indian Great Blue Heron. Garzón Ceniza. Yaguasa.

The West Indian Great Blue Heron is found fairly commonly in the coastal region of Porto Rico, but seems to be somewhat more common and generally distributed in the winter months. Possibly a few migrant Great Blue Herons from the north occur at this season, or the birds may retire to remote localities to breed during the summer months.

Usually only one or two birds are seen at a time, but on December 14, 1923 at Anegado Lagoon I noted an assemblage of six, and at Puerto Real on November 3, 1926 I noted five together.

Localities at which I have observed this bird are Añasco, Mayagüez, Joyuda, Puerto Real, Boquerón, Faro de Cabo Rojo, Parguera, Cartagena Lagoon, Anegado Lagoon, Ensenada, Guayanilla, Tallaboa, Coamo Springs, Ceiba, Toa Baja and Arecibo.

The stomach of a bird collected at Añasco contained a fish twelve inches long, and weighing about a pound.

Porto Rican specimen now in my collection:
No. 660, male, Añasco, Nov. 3, 1928.

11. *CASMERODIUS ALBUS EGRETTA* (Gmelin). Egret. Garzón Blanco.

The Egret is found in small numbers in the coastal region of Porto Rico at all times of the year, frequenting both salt and fresh water. It is occasionally found even on flooded meadows. Dr. Wet-

more found a nest near Mameyes, but I have never observed one. The birds are usually found either singly or in small groups of from two to six. On one occasion (March 23, 1929) I observed ten at the Coamo Springs Reservoir. A pair lived in a mangrove swamp at the edge of the village of Boquerón for some months in 1926 and 1927, and became very tame.

Localities at which I have observed Egrets are: Añasco, Mayagüez, Joyuda, Puerto Real, Cabo Rojo, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Cayo Enrique, Anegado Lagoon, Guánica Lagoon, Coamo Springs Reservoir, and Arecibo.

12. *EGRETTA THULA THULA* (Molina). Snowy Egret.
Garza Blanca.

The Snowy Egret is found regularly in the coastal region of Porto Rico, but can scarcely be said to be common.

Fifteen or twenty pairs nest on Cayo Enrique. The nests are placed in the mangroves at heights of from ten to twelve feet. On April 2, 1927 some nests contained eggs and others newly hatched young. The majority contained three eggs or young, although a few had only two. One nest contained two eggs and one newly hatched young, not yet dry. The young had dark bills and skin and were covered with a white fuzzy down. The adults at this time were wearing their nuptial plumes. They were very wary and took flight long before I got near the nests.

On March 22, 1928 only ten nests were found, two of which contained eggs. The rest contained newly hatched young.

On August 15, 1927 a few nests still had eggs, but most of the birds had young which could scramble around, but were not yet able to fly.

I have found the Snowy Egret at Cartagena Lagoon at all times of the year. My records for localities other than Cartagena Lagoon and Cayo Enrique are but few. A bird was seen on frequent occasions during March and May, 1930 near the mouth of the Guanajibo River at Mayagüez. Three were seen at Joyuda on April 6, 1927, two on November 28, 1929, and two on May 16, 1930. At Parguera I saw eight on February 16, 1929, and at the Coamo Springs Reservoir five on May 26, 1929. Two birds were noted at Arecibo on April 18 and 20, 1930.

Porto Rican specimen now in my collection:
No. 5, female, Cartagena Lagoon, Sept. 25, 1926.

13. *HYDRANASSA TRICOLOR RUFICOLLIS* (Gosse). Louisiana Heron. Garza de Vientre Blanca.

A few years ago the Louisiana Heron was fairly common at Cartagena Lagoon, but now it is rarely seen there. I never found it common at other localities on the island, and in the past few years it has been rarer than ever. Indeed, I have not seen one elsewhere than at Cartagena Lagoon since December, 1928.

My records other than at Cartagena Lagoon are as follows: Mayagüez, (January, 1922; September 17, 1927; April 14, 19, May 3, and December 13, 1928); Puerto Real (November 3, 1926); Boquerón (March 8, 1924, December 18, 1926, and February 14, 1927); Cayo Enrique (April 2 and August 15, 1927; possibly one or two pairs nesting); Anegado Lagoon, (March 4, 1922).

14. *FLORIDA CAERULEA CAERULESCENS* (Latham). Southern Little Blue Heron. Garza Azul. Garza Blanca. Garza Pinta.

The Little Blue Heron is a very common resident in Porto Rico, mostly near the coast, but occasionally seen in the lower foothills.

A colony of about fifteen pairs nest on Cayo Enrique. Their nests were placed in the same mangroves with those of the Snowy Egrets, about ten feet above the water. The nests were surprisingly small and frail structures of sticks. On April 2, 1927 the nests all contained either two or three eggs or newly hatched young. On August 15, 1927 only two or three nests were found, and on March 22, 1928 I noted that all the birds of this species had moved to a smaller key east of Cayo Enrique which it was impossible to examine closely on this occasion.

The stomach of a bird collected at Aguada contained nine small crabs (85 per cent); 3 *Zaitha anura* (10 per cent), and a long-legged aquatic spider (5 per cent). One collected at Cartagena Lagoon had eaten 4 adults and 1 nymph of *Zaitha anura*; 1 *Pelocoris femoratus*; 11 hardback beetless (*Dyscinetus picipes*), and 6 Hydrophilid larvae.

Localities at which I have observed this bird are: Aguadilla, Coloso, Aguada, Rincón, Añasco, Mayagüez, Hormigueros, Joyuda, Cabo Rojo, Filial Amor, Puerto Real, Boquerón, Faro de Cabo Rojo, San Germán, Sabana Grande, Lajas, Cartagena Lagoon, Maguey Island, Parguera, Cayo Enrique, Anegado Lagoon, Guánica Lagoon, Ensenada, Tallaboa, Ponce, Santa Isabel, Coamo Springs, Coamo Springs Reservoir, Salinas, Yabucoa, Fajardo, Mameyes, Loíza, Río Grande, Bayamón, Toa Baja, Manatí, and Arecibo.

Porto Rican specimens now in my collection:
No. 264 male, imm., Aguada, Dec. 1, 1926.
No. 368, female, ad., Cartagena Lagoon, Feb. 28, 1927.

15. *BUTORIDES VIRESCENS MACULATUS* (Boddaert). West Indian Green Heron. Martinete.

The Green Heron is very common in the coastal plain of Porto Rico, and also occurs along stream valleys well up into the hills.

Green Herons usually nest singly, building their crude platforms of sticks in trees which are often at a considerable distance from water. On April 7, 1929 at Algarrobo I found a nest built on the fronds of a spiny *corozo* palm, a most inaccessible position. By climbing a nearby tree I could see the two light greenish-blue eggs which the nest contained. During the breeding season the birds hide in the dense foliage of the tree tops, and at frequent intervals, often in the night, emit gulping *wullp* sounds.

Green Herons were observed by me at the following localities: Aguada, Rincón, Añasco, Mayagüez, Las Marías, Hormigueros, Cabo Rojo, San Germán, Joyuda, Puerto Real, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Parguera, Maguey Island, Anegado Lagoon, Guánica Lagoon, Ensenada, Peñuelas, Pastillo, Santa Isabel, Coamo Springs, Coamo Springs Reservoir, Guayabal Reservoir, Villalba, Salinas, Patillas, Humacao, Caguas, San Lorenzo, El Río, Mameyes, Martín Peña, Bayamón, Toa Baja, San Vicente, Laguna Tortuguera, Algarrobo, Manatí, Barceloneta, Arecibo, Hatillo, Cidra, Comerío, Naranjito, Adjuntas and Quebradillas.

A stomach from Mameyes contained 7 adult cockroaches and 1 large cockroach nymph.

Porto Rican specimens now in my collection:
No. 6, male, Cartagena Lagoon, Sept. 30, 1924.
No. 7, male, Mameyes, Oct. 12, 1926.

16. *NYCTICORAX NYCTICORAX NAEVIUS* (Boddaert). Black-crowned Night Heron. Yaboa.

This species is a fairly common bird at Cartagena Lagoon, and there is a small nesting colony on Cayo Enrique. On March 1, 1928 I saw one at Añasco, and on March 15, 1928 a boy brought me an adult male with a nuptial plume which he had just shot by the Yagüez River in Mayagüez.

At Cayo Enrique on April 2, 1927 four nests of this species were found, one with five, two with four, and one with three eggs. On

March 22, 1928 eight nests were found in this colony. All contained eggs. Sets of two, three, four and five eggs were noted. The nests were placed in the mangroves at heights of about fifteen feet. They were at the opposite end of the key from that on which the Snowy Egrets and Little Blue Herons nested.

Porto Rican specimen now in my collection:
No. 597, male adult, Mayagüez, March 15, 1928.

17. *NYCTANASSA VIOLACEA JAMAICENSIS* (Linné). Yellow-crowned Night Heron. Yaboa.

I have not found this species very commonly in Porto Rico, though it is fairly well distributed on the coastal plain.

There is a small nesting colony in an area of dense brush and small trees between Algarrobo and Laguna Tortuguera, at a distance of about a mile and a half from water. In February, 1927 Mr. William Burlingame took two fully fledged young nearly ready to fly from this colony. When I visited the colony on March 21, 1927 we succeeded in locating six nests. They were scattered over a considerable area, so it was difficult to find them all. The ground underneath the trees was strewn with white faeces and fragments of large crabs. The nests were placed at heights of from five and a half to ten feet in scrubby *jicaco* (*Chrysobalanus*) trees, in a region which was so densely overgrown with brush that the nests were visible only a few feet away. At the time of my visit four of the nests were deserted, the young evidently having just left. Of the other two nests, one contained one large blue egg, and the other three. The eggs in the latter set measured 54 × 38; 54 × 41, and 53 × 38 millimeters.

At the time of the hurricane of September 13, 1928 the colony was deserted, but a new one was formed in a similar brushy region a quarter of a mile distant. On April 7, 1929 I was able to locate only three nests in the new colony. One was empty. The second was ten feet from the ground in a *cupey* tree, and contained one egg. The third was five feet from the ground on the branch of a *jicaco* tree partly blown over by the hurricane. It contained two young at the stage where the feathers were just beginning to break out from the cases, giving them a very bristly appearance. There was also a dead young bird in the nest about half the size of the living young. The young were very savage, making loud screeching sounds, and sticking out their bills at intruders. At times they made low guttural sounds. While we were examining the nest an adult remained perched in a nearby tree watching the proceedings. The iris of the

young birds was dull yellow. The upper mandible was dusky, tinged with yellowish at the base. The lower mandible was dull yellow tinged with dusky at the tip. The legs were dull yellow with a greenish tinge.

In addition to Algarrobo I have observed this species at Aguada (November 5, 1927); Mayagüez, (sixteen observations); Joyuda (nine observations); Puerto Real (November 3, 1926); Faro de Cabo Rojo (May 14, 1927); Cartagena Lagoon, several records, the most recent being a flock of three adults seen on May 10, 1930; Santurce (March 21, 1930), and San Juan (October 14, 1926).

18. *BOTAURUS LENTIGINOSUS* (Montagu). Bittern. Yaboa.

My only Porto Rican record for the Bittern is that which I have already published (one seen at Cartagena Lagoon on November 30, 1923).

19. *IXOBRYCHUS EXILIS EXILIS* (Gmelin). Least Bittern. Martinete Chico.

The Least Bittern has become more common at Cartagena Lagoon in recent years. On April 27, 1929 I counted fifteen there. Aside from Cartagena Lagoon I have only two Porto Rican records, one seen at Guánica Lagoon on October 3, 1924 and one at Anegado Lagoon on August 16, 1927.

Porto Rican specimen now in my collection:
No. 732, male, Cartagena Lagoon, April 27, 1929.

20. *DENDROCYGNA ARBOREA* (Linné). West Indian Tree Duck. Chiriría.

Both this species and *D. autumnalis* are found in Porto Rico, but the majority of the specimens that I have observed closely enough for identification have been *autumnalis*. On September 22, 1928 I saw at Cartagena Lagoon a flock of nine birds which were certainly *arborea*.

21. *DENDROCYGNA AUTUMNALIS* (Linné). Black-bellied Tree Duck. Chiriría.

Although I have no specimens to prove my point, I feel positive that the most common tree duck in Porto Rico is this species. I have on numerous occasions had excellent opportunities for observing this bird under favorable conditions at Cartagena Lagoon. On November 20, 1926 I saw one fly into a dense growth of guinea grass on Ensenada point, from which it was impossible to flush it.

22. *MARECA AMERICANA* (Gmelin). Baldpate. Pato Lablanco.

My only records for the Baldpate are those already published in my "Birds of the Cartagena Lagoon".

23. *DAFILA ACUTA TZITZIHOA* (Vieillot). Pintail. Pato Pescuezilargo.

In addition to the records which I have already published, I can record a male seen at Anegado Lagoon on March 7, 1927, and a male at Cartagena Lagoon on December 10, 1927.

24. *POECILONETTA BAHAMENSIS BAHAMENSIS* (Linné). Bahama Duck. Pato Inglés.

The Bahama Duck is a fairly common resident at Cartagena, Anegado and Guánica Lagoons. Mr. Juan Zalduondo of Fajardo tells me that a few stay all the year at a small brackish lagoon on Piñero Island near Fajardo, and presented me with a specimen from that locality. On August 18, 1927 I observed one flying low over the city of Mayagüez at dusk.

Porto Rican specimen now in my collection:
No. 655, female, Piñero Island, near Fajardo, May 26, 1928.

25. *QUERQUEDULA DISCORS* (Linné). Blue-winged Teal. Pato Celecel. Pato de la Florida.

The Blue-winged Teal is a common winter resident at Cartagena and Anegado Lagoons. I have not recorded it elsewhere on the island. Fall arrival dates at Cartagena Lagoon are September 6, 1924, September 25, 1926, and September 22, 1928. My latest spring dates are May 2, 1924, April 7, 1928, and April 13, 1929.

26. *SPATULA CLYPEATA* (Linné). Shoveller. Pato Cuchareta.

At Cartagena Lagoon on December 16, 1928 Mr. James Bond and I made careful observations of a female Shoveller in company with four Lesser Scaups. This is my second positive Porto Rican record of the species.

27. *MARILA AFFINIS* (Eyton). Lesser Scaup Duck. Pato Turco.

The Lesser Scaup is a common and regular winter resident in Porto Rico. At Cartagena Lagoon it is especially common, and I have counted as many as three hundred in one day (January 12, 1929). I have also recorded the species at Guayabal Reservoir (January 5, 1924 and November 30, 1929); Coamo Springs Reservoir

(March 18, 1928 and March 24, 1929); Boquerón (one on November 6, 1926), and Mayagüez (migrating flock on May 5, 1924, and a crippled female on November 28, 1929).

My first fall records are: September 23, 1924 (Cartagena Lagoon); November 6, 1926 (Boquerón), and November 10, 1928 (Cartagena Lagoon). My latest spring records are: May 16, 1924, May 12, 1928, April 13, 1929 and April 12, 1930, all at Cartagena Lagoon.

28. *ERISMATURA JAMAICENSIS JAMAICENSIS* (Gmelin). West Indian Ruddy Duck. Chorizo.

The Ruddy Duck is an abundant permanent resident on the larger bodies of fresh water. On Cartagena Lagoon it is abundant and nests. I have counted as many as 600 in one day there.

When there is water in Anegado and Guánica Lagoons many are found there. On the Guayabal Reservoir I found 100 on November 30, 1929, and lesser numbers on other dates. When the Coamo Springs Reservoir contains water many Ruddy Ducks occur there. On February 10, 1929 I found about 300 on the reservoir. On February 22, 1930 the reservoir was very nearly dry, but in the tiny pool of water that was left seven females were swimming around. Miss Nina G. Spaulding reports seeing a number at Laguna Rica on April 27, 1930.

Porto Rican specimens now in my collection:

No. 10, male, Cartagena Lagoon, July 19, 1925.
No. 11, female, Cartagena Lagoon, March 1, 1924.
No. 357, female, Cartagena Lagoon, January 30, 1927.
No. 358, male, Cartagena Lagoon, January 30, 1927.

29. *CATHARTES AURA AURA* (Linné). Southern Turkey Vulture. Aura Tiñosa.

The Turkey Vulture continues to be restricted to its limited range in the southwestern part of the island. I have found the species from Coamo Springs on the east to Mayagüez on the west, but it is extremely rare at both extremities of its range. My records are as follows: Coamo Springs (one on December 1, 1929); Ponce (numerous records); Tallaboa (fairly common); Peñuelas (December 5, 1926); Guayanilla (several records); Yauco (common); Ensenada (common); Guánica Lagoon (common); Anegado Lagoon (common); Lajas (common); Parguera (common); Sabana Grande (several records); Cartagena Lagoon (common); Boquerón (fairly common); Faro de Cabo Rojo (several records); Monte Grande

(August 17, 1927); Cabo Rojo, (three records); San Germán (several records); Hormigueros (three records); Mayagüez (one seen on September 28, 1926).

The greatest number I have ever had in sight at one time was twenty-eight near Lajas on January 5, 1930.

30. *ACCIPITER STRIATUS VENATOR* Wetmore. Porto Rican Sharp-shinned Hawk. Falcón.

This hawk must be considered very scarce at present. In my many trips to the hill country near Maricao I have noted it on only two occasions. On January 1, 1922 I observed one in the hills east of Mayagüez, and on April 16, 1922 one near Montoso Mountain.

31. *BUTEO BOREALIS JAMAICENSIS* (Gmelin). West Indian Red-tailed Hawk. Guaraguau. Lechuza.

The Red-tailed Hawk is a fairly common resident, particularly in the hills. It is usually seen singly or in pairs, but on November 24, 1926 I observed a flock of six adults soaring over Montoso Mountain.

The stomach of a bird collected near Lajas on March 5, 1930 contained the feathers and meat of an *Agelaius xanthomus*, also a few seeds which were evidently from the Blackbird's stomach.

I have recorded the species at Rincón, Añasco, Mayagüez, Maricao, Montoso Mountain, Consomo, Las Vegas, Las Marías, Boquerón, Cartagena Lagoon, Lajas, Anegado Lagoon, Guánica Lagoon, Coamo Springs, hills between Villalba and Ciales, El Yunque, Vega Alta, Manatí, and the hills between Arecibo and Utuado.

32. *CIRCUS HUDSONIUS* (Linné). Marsh Hawk.

The Marsh Hawk is a rare winter visitant to Porto Rico, where I have observed it only at Cartagena Lagoon. All the examples seen were in the brown plumage. I have recorded it on the following occasions: November 30, December 7, 22 and 27, 1923; December 10, 1927; March 10, 1928; January 12 and March 9, 1929, and February 8, 1930. On each occasion only one bird was seen except on December 22, 1923, when two were noted.

33. *PANDION HALIAETUS CAROLINENSIS* (Gmelin). Osprey. Aguila del Mar.

The Osprey is an uncommon winter visitant to Porto Rico. Early fall records are September 27, 1924 (Cartagena Lagoon); November 3, 1926 (Puerto Real); and November 2, 1929 (Mayagüez). Late spring dates are March 22, 1922 (Boquerón); March 11, 1924

(Cartagena Lagoon); April 17, 1927 (Mayagüez); April 21, 1928 (Mayagüez), and April 28, 1929 (Joyuda). In addition to the localities mentioned above I have observed the Osprey at El Faro de Cabo Rojo.

34. *FALCO PEREGRINUS ANATUM* Bonaparte. Duck Hawk. Falcón.

The Duck Hawk is an uncommon winter visitant to Porto Rico. I have seen it catch Antillean Gallinules and Ruddy Ducks, and make unsuccessful attempts to capture Little Blue Herons and Common Terns.

Early fall records are: September 30, 1924 (Cartagena Lagoon); December 10, 1927 (Cartagena Lagoon); December 8, 1928 (Cartagena Lagoon), and November 18, 1929 (Joyuda). Late spring dates are: April 1, 1922 (Anegado Lagoon); April 7, 1928 (Cartagena Lagoon), and April 18, 1929 (Boquerón).

All my other records pertain to the places mentioned above except for one bird seen at Hormigueros on December 16, 1928.

35. *FALCO COLUMBARIUS COLUMBARIUS* Linné. Pigeon Hawk. Falcón.

The Pigeon Hawk is a regular but rather uncommon winter resident in Porto Rico, found sometimes in the hills, but more often in the vicinity of lagoons and reservoirs. One or two birds usually frequent Cartagena Lagoon in winter and it is not unusual to see the species at other localities. I have recorded it at Coloso, Mayagüez, San Germán, Sabana Grande, Cartagena Lagoon, Anegado Lagoon, the Coamo Springs Reservoir, a small pond near Maunabo, and at Quebradillas.

Early arrival dates are: October 20, 1924 (Cartagena Lagoon); October 30, 1926 (Cartagena Lagoon), December 1, 1928 (Maunabo), and October 31, 1929 (Mayagüez).

Late Spring dates are April 12, 1922 (Quebradillas); April 25, 1924 (Sabana Grande); April 21, 1928 (Cartagena Lagoon), April 13, 1929 (Cartagena Lagoon), and April 1, 1930 (Mayagüez).

Porto Rican specimen now in my collection:
No. 671, female, Cartagena Lagoon, Dec. 16, 1928.

36. *FALCO SPARVERIUS CARIBAEARUM* (Gmelin). Antillean Sparrow Hawk. Falcón.

The Sparrow Hawk is a common resident in Porto Rico. It is particularly abundant in the dry south coastal region, but it is also locally quite abundant at certain places on the north coast.

The contents of five stomachs were examined, and the following items were found: Crickets (*Gryllus assimilis*), 20 per cent; mice, 38 per cent; Anolis lizards, 18 per cent; Anolis eggs, 2 per cent; centipede fragments, 2 per cent; millipedes (*Julus caesar*), 8 per cent; Long-horned grasshoppers (*Neoconocephalus triops*), 8 per cent; gravel, 4 per cent (in one stomach).

Near Mayagüez I observed a pair nesting in a hole twenty feet above the ground in a dead cocoanut palm in the early part of May, 1928. When one of my students climbed up to the hole the parent birds made repeated dashes at his face, coming within two or three inches of it.

I find the Sparrow Hawk recorded in my notes from the following localities: Aguadilla, Coloso, Aguada, Rincón, Añasco, Las Marías, Maricao, Mayagüez, Hormigueros, San Germán, Sabana Grande, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon (rare); Lajas, Parguera, Anegado Lagoon, Guánica Lagoon, Guánica, Yauco, Guayanilla, Peñuelas, Tallaboa, Ponce, Santa Isabel, Jayuya, Coamo Springs, Villalba, Juana Díaz, Coamo-Aibonito Road, Aibonito-Cayey Road, Salinas, Guayama, Bayamón, Palo Seco, Vega Baja, Algarrobo, Manatí, Barceloneta, Arecibo, Florida, Hatillo, Camuy and Quebradillas.

Porto Rican specimens now in my collection:

No. 268, female, Las Marías, Dec. 4, 1926.
No. 269, male, Las Marías, Dec. 4, 1926.
No. 615, male, Mayagüez, April 18, 1928.
No. 741, female, Mayagüez, Oct. 29, 1929.

37. *RALLUS LONGIROSTRIS CARIBAEUS* Ridgway. Caribbean Clapper Rail. Pollo de Manglar.

The Clapper Rail is a common inhabitant of the mangrove swamps of Porto Rico, but it is much more often heard than seen. At certain times of the year it is very silent, and may easily be overlooked. It leaves the brackish water mangrove swamps at times of low water, and so may be absent at places where a short time before it was abundant.

By patiently watching small openings in mangrove swamps I obtained three specimens, one of which was retained for my own collection. The stomach contents of these specimens was found to consist entirely of fiddler crabs (*Uca pugnax rapax*).

I have found Clapper Rails in mangrove swamps at Joyuda, Puerto Real, Boquerón, Faro de Cabo Rojo, Parguera and Fajardo. My specimens were all collected at Boquerón and Puerto Real.

Porto Rican specimen now in my collection:
No. 720, male, Boquerón, April 4, 1929.

38. *PORZANA CAROLINA* (Linné). Sora. Gallareta Chiquita.

The Sora is a regular and fairly common winter resident at those fresh water lagoons which have sufficient vegetation to provide suitable cover. They are especially common at Cartagena Lagoon, where I have counted as many as 150 in one day (February 11, 1928). I have also observed Soras at Anegado and Guánica Lagoons, and at a small swamp near Mayagüez.

The stomach of a specimen collected was filled with seeds of Compositae. It also contained gravel to the extent of 45 per cent of the contents.

Early fall dates are October 14, 1924 and October 13, 1928. Late spring dates are April 8, 1922; April 18, 1924, March 28, 1927, and April 7, 1928. These migration dates were all obtained at Cartagena Lagoon.

Porto Rican specimen now in my collection:
No. 369, female, Cartagena Lagoon, Feb. 28, 1927.

39. *PORZANA FLAVIVENTER HENDERSONI* Bartsch. Yellow-bellied Rail. Gallareta Chiquita.

The Yellow-bellied Rail is a not uncommon resident at Cartagena Lagoon, although on account of its retiring habits it easily escapes notice. The largest number I have observed on any one day is four. On April 1, 1922 I observed one at Anegado Lagoon. The only two specimens which I have collected are in the Cornell University Museum.

40. *IONORNIS MARTINICUS* (Linné). Purple Gallinule. Galareta Inglés.

The Purple Gallinule is one of the birds which has increased in abundance during the time that I have been in Porto Rico. Now I should call it a distinctly common bird at Cartagena Lagoon, where it is not unusual to note as many as forty birds in the course of a morning's field work. I have also recorded the species on two occasions at Mayagüez, and at Guánica Lagoon. A stomach from Cartagena Lagoon contained *Persicaria* seeds, 88 per cent; and coarse grass, 12 per cent. A stomach from Mayagüez contained nothing but a quantity of vari-colored gravel.

Porto Rican specimens now in my collection:
No. 226, male, imm., Cartagena Lagoon, Oct. 30, 1926.

No. 372, male, ad., Mayagüez, March 5, 1927.
No. 627, female, ad., Mayagüez, May 7, 1927.

41. *GALLINULA CHLOROPUS PORTORICENSIS* Danforth. Antillean Gallinule. Gallareta. Yagareta.

The Antillean Gallinule is an abundant resident at all the fresh water lagoons in Porto Rico, and is also found at some of the brackish water lagoons and smaller swamps, and in the larger river marshes, and occasionally even in the mangrove swamps. I have found large numbers of their nests and eggs at Cartagena and Anegado Lagoons.

I have recorded the species at Aguadilla (one record); Añasco (one record); Mayagüez (common at a small fresh water swamp, and a few may usually be seen near the mouth of the Guanajibo River); Joyuda (in cutover mangrove swamps); Faro de Cabo Rojo (scarce in mangrove swamps); Cartagena Lagoon (abundant); Anegado Lagoon (abundant); Guánica Lagoon (common); Salinas (recorded once in mangrove swamp); Guayabal Reservoir (a few); Coamo Springs Reservoir (common); Toa Alta (one seen at the river); Laguna Tortuguera (a few); Arecibo (numerous records in river marshes and other smaller marshes); Quebradillas (in small marshes along the Guajataca River).

Porto Rican specimens now in my collection:
No. 14, female, Cartagena Lagoon, April 4, 1924.
No. 374, female, Cartagena Lagoon, March 7, 1927.
No. 628, female, Aguadilla, May 7, 1928.
No. 859, male, Mayagüez, May 18, 1930.

42. *FULICA CARIBAEA* Ridgway. Caribbean Coot. Gallinazo.

The Coot is an abundant resident on the larger lagoons and reservoirs of Porto Rico. Their numbers greatly increased during the period following the hurricane of September, 1928. At that time the lagoons were filled, and kept full by the unusually heavy rains which continued for more than a year afterwards. They became so deep and choked with vegetation that egg hunters could not get to the Coot's breeding places either on foot or by boat. This gave the birds a great opportunity to increase. Now it is not at all unusual to see upwards of five thousand Coots in a day at Cartagena Lagoon, and large numbers at other suitable localities.

Coots are abundant at Cartagena Lagoon, and common at Anegado Lagoon, Guánica Lagoon, Guayabal Reservoir, and Coamo

Springs Reservoir. I have observed a few at Laguna Tortuguera, and one at a small slough near Arecibo.

Porto Rican specimens now in my collection:

No. 15, male, Cartagena Lagoon, Sept. 9, 1924.
No. 16, sex? Cartagena Lagoon, July 19, 1925.
No. 225, male, Cartagena Lagoon, Oct. 30, 1926.
No. 629, male, Cartagena Lagoon, May 12, 1928.

43. *CHARADRIUS NIVOSUS TENUIROSTRIS* Lawrence. Cuban Snowy Plover.

On May 5, 1928 I collected a male at El Faro de Cabo Rojo, on a white sandy salt flat not far from some mangroves. There the white coloration of the bird was very protective. Its testes were large. Its stomach was nearly empty, but contained a few fragments of Staphylinid beetles and some gravel. The species may eventually be found to breed in Porto Rico, as it is known to breed in St. Croix, and it presumably breeds in Haiti.

Porto Rican specimen now in my collection:

No. 626, male, Faro de Cabo Rojo, May 5, 1928.

44. *CHARADRIUS SEMIPALMATUS* Bonaparte. Semipalmated Plover. Putilla.

The Semipalmated Plover is a rather uncommon winter resident along the coasts of Porto Rico. I have collected specimens at Ensenada, and have also seen the species at Mayagüez, Joyuda, Rat Island, Faro de Cabo Rojo, and Salinas.

Early fall dates are: August 16, 1927 (Ensenada); September 10, 1928 (Mayagüez), and September 16, 1929 (Joyuda).

Late spring dates are: April 26, 1924, April 20, 1929 (both at El Faro de Cabo Rojo), and April 5, 1930, at Mayagüez.

These birds are seen most commonly from September to November.

45. *PAGOLLA WILSONIA WILSONIA* (Ord). Wilson's Plover. Putilla. Playero.

The Wilson's Plover is a not uncommon resident bird in Porto Rico, found principally along sandy beaches. It is most abundant at El Faro de Cabo Rojo, where it showed all indications of breeding in May, although I have never actually found nests. From 200 to 350 birds can usually be seen at this place. A few can usually be seen at Ensenada, I have several times noted the species at Mayagüez and Joyuda, and I have one record from Boquerón. It is oc-

casionally found by bodies of fresh water. Of such records I have the following: Cartagena Lagoon (one collected on June 3, 1924 and two seen on October 1, 1927); Anegado Lagoon (five seen on September 29, 1926); Guánica Lagoon (fifteen seen on October 2, 1926); Sabana Grande (one seen at the edge of a small reservoir on October 6, 1926).

Two stomachs from Boquerón and Ensenada contained nothing but Crustacean remains and a little gravel.

Porto Rican specimens now in my collection:
No. 23, male, Faro de Cabo Rojo, April 27, 1924.
No. 25, female, Ensenada, Oct. 9, 1926.

46. *OXYECHUS VOCIFERUS RUBIDUS* Riley. West Indian Killdeer. Putilla. Playero.

The West Indian Killdeer is a permanent resident in Porto Rico, but is apparently much less abundant in the winter months than during the rest of the year. Possibly it is because they spread around more in the winter.

I have never noted migrant Killdeers from North America in Porto Rico, although they are not uncommon in the Virgin Islands. In my recent paper on the birds of the Virgin Islands I have given measurements of my specimens from those islands and from Porto Rico.

I have recorded Killdeers at the following localities: Mayagüez (Three records, November 7 and 22, 1928, and November 18, 1929); Hormigueros (August 29, 1927 and November 23, 1927); Filial Amor (June 14, 1924); San Germán (May 10, 1928, April 27, 1929 and November 18, 1929); Sabana Grande (October 6, 1926); Boquerón (January 6, 1922, October 17, 1924, May 14, 1927 and September 3, 1928); Faro de Cabo Rojo (April 25, 1924); Cartagena Lagoon (common; breeds, but scarce in winter); Lajas (numerous records at all times of the year); Parguera (October 20, 1929); Anegado Lagoon (common); Guánica Lagoon (common); Ensenada (February 26, 1927, April 24, 1927, October 16, 1927, January 21, 1928, February 22, 1928, September 22, 1928, and November 3, 1928); Yauco (October 9, 1926); Pastillo (April 12, 1927); Santa Isabel (December 1, 1929 and January 26, 1930); Guayabal Reservoir (November 30, 1929); Coamo Springs Reservoir (March 18, 1928, April 29, 1928, March 22, 23 and 24, 1929; September 8, 1929); Humacao (January 4, 1924); Río Piedras (October 26, 1927); Alga-

rrobo (March 19 and 21, 1927; June 7 and 8, 1927, and April 20, 1930); Arecibo (October 14, 1926, March 9, 20 and 22, 1930, and April 18 and 20, 1930); Quebradillas (March 22, 1930).

A stomach from Arecibo contained entirely animal matter (mostly smooth white caterpillars, and a few beetle fragments). It also had a large amount of coarse sand.

Porto Rican specimens now in my collection:
No. 21, male, Cartagena Lagoon, Sept. 23, 1924.
No. 22, male, Arecibo, Oct. 14, 1926.

47. *PLUVIALIS DOMINICUS DOMINICUS* (Müller). Golden Plover. Playero.

The Golden Plover is a rare migrant in Porto Rico. On September 29, 1926 I believe I saw a flock of four at Anegado Lagoon, but I was unable to collect any.

48. *SQUATAROLA SQUATAROLA CYNOSURAE* Thayer and Bangs. Black-bellied Plover. Playero.

Formerly the Black-bellied Plover was a very rare visitant in Porto Rico. Until November 3, 1926, when I noted a flock of six birds at Puerto Real, I had never seen the species in the island. Since then it has steadily increased in numbers until now it is a rather common winter resident. I see it regularly at numerous localities along the shore throughout the winter. A stomach was full of fragments of *Hippa* crabs.

Localities at which I have noted the species are: Mayagüez (a few along the shore throughout the winter); Puerto Real (November 3, 1926); Boquerón (common); Faro de Cabo Rojo (common); Cartagena Lagoon (six on March 28, 1927); Ensenada (common).

Early fall dates are November 3, 1928 (Puerto Real); August 16, 1927 (Ensenada); September 3, 1928 (Boquerón), and October 4, 1929 (Mayagüez).

Late spring dates are: May 15, 1927, May 5, 1928, and April 20, 1929, (at El Faro de Cabo Rojo), and May 10, 1930 (at Mayagüez).

Porto Rican specimens now in my collection:
No. 663, female, Faro de Cabo Ropo, Sept. 29, 1928.
No. 721, female, Boquerón, March 7, 1929.

49. *ARENARIA INTERPRES MORINELLA* (Linné). Ruddy Turnstone. Playero.

Ruddy Turnstones are common winter residents along the coasts of Porto Rico. They are in winter plumage most of the time they are with us, but molt into their breeding plumage before leaving in the spring. They are often found in company with Black-bellied Plovers and Sanderlings along the beaches. On April 4, 1927 at Mayagüez I killed thirteen Turnstones and six Sanderlings at one shot. The contents of twelve of the Turnstone stomachs were examined, and found to contain: Fragments of Molluscs 50.8 per cent; unidentified animal matter, 7.5 per cent, seeds and pulp of fruits, 41.7 per cent; also sand to the extent of 12.7 per cent of the total contents was found.

Localities at which I have observed Turnstones are: Mayagüez (common); Joyuda (September 16, 23 and December 9, 1929); Boquerón (April 16, 1928 and March 7, 1929); Faro de Cabo Rojo (common); Cayo Enrique (April 2, 1927 and March 22, 1928); Parguera (August 15, 1927); Ensenada (October 9, 1926, August 16, 1927, and September 22, 1928); Guayanilla (November 24, 1927).

Early fall dates are: September 27, 1926 (Mayagüez); August 15, 1927 (Parguera); September 10, 1928 (Mayagüez), and September 16, 1929 (Joyuda).

Late spring dates are: April 27, 1924 (Faro de Cabo Rojo); May 14, 1927 (Faro de Cabo Rojo); May 5, 1928 (Faro de Cabo Rojo); April 24, 1929 (Mayagüez), and May 10, 1930 (Mayagüez).

Porto Rican specimens now in my collection:

No. 378, male, Mayagüez, April 4, 1927.
No. 379, female, Mayagüez, April 4, 1927.
No. 380, female, Mayagüez, April 4, 1927.
No. 381, female, Mayagüez, April 4, 1927.
No. 382, female, Mayagüez, April 4, 1927.
No. 383, male, Mayagüez, April 4, 1927.
No. 384, female, Mayagüez, April 4, 1927.
No. 385, male, Mayagüez, April 4, 1927.
No. 386, female, Mayagüez, April 4, 1927.
No. 387, male, Mayagüez, April 4, 1927.
No. 388, male, Mayagüez, April 4, 1927.
No. 389, female, Mayagüez, April 4, 1927.
No. 390, male, Mayagüez, April 4, 1927.

50. *CAPELLA DELICATA* (Ord). **Wilson's Snipe.**

The Wilson's Snipe is a winter resident of somewhat irregular abundance. In the winter of 1926–27 it was exceptionally abundant. On January 29, 1927 I counted 250 at Cartagena Lagoon. Sometimes as many as twenty would flush at once, but they would fly in as many different directions, making no attempt to keep together as a flock. They frequented mostly the grassy areas where there was opportunity for concealment. I have been able to learn no Porto Rican name for the species.

Two stomachs contained nothing but comminuted insects, among which a few fragments of Carabidae were recognized.

I have observed Snipe only at Cartagena, Anegado and Guánica Lagoons, with the exceptions of a bird noted in a canefield at Añasco on December 26, 1923, and one in a small swamp at Mayagüez on February 13, 1924.

Early fall dates are: October 4, 1924, October 30, 1926, December 10, 1927 and October 13, 1928 (all at Cartagena Lagoon).

Late spring dates are: March 22, 1922, April 15, 1924, March 28, 1927, and April 7, 1928 (all at Cartagena Lagoon).

Porto Rican specimens now in my collection:

No. 370, female, Cartagena Lagoon, Feb. 28, 1927.

No. 595, female, Guánica Lagoon, Feb. 22, 1927.

51. *PHAEOPUS HUDSONICUS* (Latham). **Hudsonian Curlew.**

On February 25, 1928 I noted four on the mudflats in a mangrove swamp at Boquerón, in company with Greater Yellowlegs and Black-bellied Plovers. On September 3, 1928 I saw two at the same place. On September 29, 1928 one was observed flying around the marsh at El Faro de Cabo Rojo.

52. *ACTITIS MACULARIA* (Linné). **Spotted Sandpiper. Putilla.**

The Spotted Sandpiper is a very common winter resident in Porto Rico, found on seabeaches, at lagoons, and along streams, occasionally along the smaller mountain streams and even in damp canefields.

I have recorded the species at Aguada, Añasco, Mayagüez, Joyuda, Puerto Real, Boquerón, Hormigueros, San Germán, Faro de Cabo Rojo, Cartagena Lagoon, San Germán, Sabana Grande, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Guayabal Reservoir, Coamo Springs, Coamo Springs Reservoir, San Lorenzo, Algarrobo, Manatí, and Quebradillas.

Early fall dates are: August 13, 1924 (Cartagena Lagoon); August 13, 1927 (Cartagena Lagoon); August 29, 1928 (Mayagüez), and August 27, 1929 (Mayagüez).

Late spring dates are: May 23, 1924 (Cartagena Lagoon); April 18, 1927 (Cartagena Lagoon); May 8, 1928 (Añasco), April 27, 1929 (San Germán), and May 13, 1930 (Mayagüez).

Porto Rican specimen now in my collection:

No. 48, male, Cartagena Lagoon, Feb. 19, 1924.

53. *TRINGA SOLITARIA SOLITARIA* Wilson. Solitary Sandpiper. Putilla.

The Solitary Sandpiper is a tolerably common visitor to Porto Rico in the fall migration, but very rare in the spring. None are found here in the winter. While with us it occurs singly or in small flocks of two or three, mostly along streams, or in flooded meadows, often near the lagoons, but seldom right at the lagoon edges. Sometimes I have seen these birds at small roadside puddles.

I have recorded the species at Añasco, Mayagüez, Puerto Real, San Germán, Filial Amor, Cabo Rojo, Boquerón, Cartagena Lagoon, Anegado Lagoon, Guánica Lagoon, Guayabal Reservoir, and the Coamo Springs Reservoir.

Early fall dates are: August 30, 1924 (Cartagena Lagoon); September 17, 1926 (Mayagüez); September 24, 1927 (Mayagüez); September 9, 1928 (Mayagüez), and September 7, 1929 (Guayabal Reservoir).

Late fall dates are: October 11, 1924 (Mayagüez); October 2, 1926 (Guánica Lagoon); October 8, 1927 (Cartagena Lagoon); November 2, 1928 (Mayagüez), and October 10, 1929 (Mayagüez).

My only spring dates are of a single bird seen at Anegado Lagoon March 4, 1922, one seen at San Germán March 24, 1928, one collected from a flock of three at Puerto Real on April 16, 1929, and one seen at San Germán April 16, 1929.

Porto Rican specimen now in my collection:

No. 731, male, Puerto Real, April 16, 1929.

54. *CATOPTROPHORUS SEMIPALMATUS SEMIPALMATUS* (Gmelin). Willet. Playante.

Formerly I believed that the Boquerón colony of Willets might be resident, but further observations have led me to believe that these birds are strictly migratory in Porto Rico. Every winter a small colony of from twenty to twenty-five Willets winter at some man-

grove-bordered mudflats near Boquerón, where I took two specimens now in the Cornell University museum. From five to ten can usually be seen at some mangrove-bordered salt ponds at Puerto Real.

On September 23, 1924 I observed one at Cartagena Lagoon. At El Faro de Cabo Rojo I saw two on April 27, 1924, and one on September 29, 1928.

Early fall dates are: September 23, 1924 (Cartagena Lagoon), and September 29, 1928 (Faro de Cabo Rojo).

Late spring dates are: April 27, 1924 (Faro de Cabo Rojo); April 16, 1928 (Boquerón), and April 18, 1929 (Boquerón).

Porto Rican specimen now in my collection:
No. 45, female, Boquerón, Feb. 22, 1924.

55. *TOTANUS FLAVIPES* (Gmelin). Lesser Yellowlegs. Putilla. Playante.

The Lesser Yellowlegs is one of the commonest of the northern shorebirds which visit Porto Rico. It is somewhat more abundant in fall and spring than during the middle of the winter. A few which are probably non-breeding individuals even stay through the summer. They are found most abundantly at the fresh water lagoons, mangrove-bordered mudflats, and saltponds where salt is made by the open-air evaporation of seawater. Sometimes they are found along rivers, and even at small limestone sinkpools and on flooded meadows. I have never found them along sandy seabeaches.

A stomach from Guánica Lagoon contained Hydrophilid larvae and some unidentified insect fragments.

Localities at which I have recorded these birds are: Aguadilla (October 27, 1929); Añasco, Mayagüez, Joyuda (October 28, 1928); Cabo Rojo, Puerto Real, Boquerón (common); San Germán; Faro de Cabo Rojo, Cartagena Lagoon (abundant); Anegado Lagoon (common); Guánica Lagoon (common); Ensenada (common); Guayabal Reservoir, Coamo Springs, Coamo Springs Reservoir, Caguas (December 23, 1929), and Arecibo (common).

Migration dates are rather difficult to obtain on account of the presence of summering individuals. The greater number seem to arrive in August and leave in April or May. October is the month of greatest abundance. The following migration dates represent fairly accurately, I believe, the arrival and departure of migrants. Arrivals: August 13, 1924 and August 13, 1927 (Cartagena Lagoon). Departures: May 14, 1927 (Faro de Cabo Rojo); April 25, 1928 (Cartagena Lagoon), April 17, 1929 (San Germán), and May 10, 1930 (Cartagena Lagoon).

Porto Rican specimens now in my collection:
No. 43, female, Cartagena Lagoon, Sept. 17, 1924.
No. 44, female, Guánica Lagoon, Oct. 2, 1926.
No. 359, male, Boquerón, Feb. 14, 1927.

56. *TOTANUS MELANOLEUCUS* (Gmelin). Greater Yellowlegs, Putilla. Playero. Playante.

Like the preceding species, this is a winter visitant from North America, but a few individuals stay through the summer, at least at Cartagena Lagoon. It is, however, much less common than the Lesser Yellowlegs, though some years it could hardly be called rare. It is found most commonly at the larger fresh water swamps, and at the mangrove-bordered salt water swamps. A stomach from Guánica Lagoon contained four large aquatic Coleopterous larvae.

I have recorded Greater Yellowlegs at Mayagüez (November 26, 1929).; Joyuda; Puerto Real; Boquerón (common); Faro de Cabo Rojo, Sabana Grande (September 13, 1926); Cartagena Lagoon (common); Anegado Lagoon (common); Guánica Lagoon (common); Ensenada (October 9, 1926 and August 16, 1927); Coamo Springs Reservoir (March 18, 1928), and Arecibo (October 14, 1926, and March 21 and 22, 1930).

Migration dates, so far as distinguishable from summering birds, are: Arrival: August 16, 1927 (Ensenada). Departures: April 22, 1922 and April 23, 1927 (Cartagena Lagoon), and March 24, 1928 (Boquerón).

Porto Rican specimen now in my collection:
No. 39, Cartagena Lagoon, June 10, 1924.

57. *PISOBIA MINUTILLA* (Vieillot). Least Sandpiper. Putilla.

The Least Sandpiper is an abundant migrant, and uncommon winter resident in Porto Rico. The last migrants in the spring scarcely leave before the first return migrants from the north arrive. I have observed the species in every month of the year except June. While with us Least Sandpipers are sometimes found on sandy beaches, but are more abundant at the edges of lagoons and at mangrove-bordered mudflats.

A stomach from Cartagena Lagoon and another from Guánica Lagoon contained 85 per cent Hydrophilid larvae; and fragments of insects (including Coleoptera), 15 per cent. Also, in one of them, gravel to the extent of 75 per cent of the stomach contents was found.

Localities at which I have recorded Least Sandpipers are: Aguada,

Mayagüez, Joyuda, Sabana Grande, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Anegado Lagoon, Guánica Lagoon, Ensenada, Coamo Springs Reservoir, Salinas, and Arecibo.

Migration dates, all at Cartagena Lagoon, are: Arrival, July 5, 1924. Late Spring dates: May 30, 1924, April 23, 1927, April 25, 1928, April 27, 1929, and May 10, 1930.

Porto Rican specimens now in my collection:
No. 34, female, Cartagena Lagoon, March 25, 1924.
No. 36, female, Cartagena Lagoon, Sept. 25, 1926.

58. *PISOBIA MELANOTOS* (Vieillot). Pectoral Sandpiper. Putilla.

The Pectoral Sandpiper is an abundant fall migrant, and a few are found in the spring migration. It occurs most frequently in damp grassy areas near lagoons, but I have found it at the edges of small pools, along rivers, on salt water mudflats, and even in dry fields far from water.

The stomachs of three birds collected at Anegado Lagoon September 29, 1926 were full of Geometrid caterpillars. They also contained 18 per cent of gravel. A stomach from Cartagena Lagoon collected September 17, 1927 contained seven cranefly larvae, also a little undetermined animal matter and one piece of quartz gravel.

Localities at which I have observed the species are: Mayagüez, Cabo Rojo, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Anegado Lagoon, Guánica Lagoon, Coamo Springs and Arecibo.

Early fall dates are August 13, 1924 and August 13, 1927 (at Cartagena Lagoon).

Late fall dates are: October 20, 1924 (Cartagena Lagoon); November 3, 1926 (Cabo Rojo); October 8, 1927 (Lajas), and October 13, 1928 (Cartagena Lagoon).

My only spring records are April 1, 1922 at Anegado Lagoon and April 27, 1924 at El Faro de Cabo Rojo.

Porto Rican specimens now in my collection:
No. 29, female, Anegado Lagoon, Sept. 29, 1926.
No. 30, female, Anegado Lagoon, Sept. 29, 1926.
No. 31, female, Anegado Lagoon, Sept. 29, 1926.
No. 550, male, Cartagena Lagoon, Sept. 17, 1927.

59. *PISOBIA FUSCICOLLIS* (Vieillot). White-rumped Sandpiper. Putilla.

This species is a rather uncommon fall migrant in Porto Rico. I have recorded it at Boquerón, Cartagena Lagoon, Guánica Lagoon,

the saltponds at Ensenada, and at the Coamo Springs Reservoir. Two stomachs from Cartagena Lagoon contained comminuted insects and a large amount of gravel.

Early fall dates are August 26, 1924 and August 13, 1927 (at Cartagena Lagoon), and September 8, 1929 (Coamo Springs Reservoir).

Late fall dates are October 20, 1924 (Cartagena Lagoon); October 9, 1926 (Ensenada); and October 8, 1927 (Cartagena Lagoon).

Porto Rican specimens now in my collection:

No. 32, male, Cartagena Lagoon, Aug. 26, 1924.
No. 33, female, Guánica Lagoon, Oct. 2, 1926.
No. 548, male, Cartagena Lagoon, Sept. 17, 1927.

60. *MICROPALAMA HIMANTOPUS* (Bonaparte). Stilt Sandpiper. Putilla.

The Stilt Sandpiper is a tolerably common fall migrant in Porto Rico, where I have observed it only at Cartagena and Guánica Lagoons. A stomach from Guánica Lagoon was mostly filled with sand, but contained a few insect fragments. One from Cartagena Lagoon was filled with comminuted animal material.

Early fall dates are: August 20, 1924 and September 17, 1927 at Cartagena Lagoon. Late fall dates are: September 27, 1924 (Cartagena Lagoon); October 2, 1926 (Guánica Lagoon); and October 1, 1927 (Cartagena Lagoon).

Porto Rican specimens now in my collection:

No. 26, female, Cartagena Lagoon, Aug. 20, 1924.
No. 27, male, Cartagena Lagoon, Aug. 20, 1924.
No. 28, female?, Guánica Lagoon, Oct. 2, 1926.
No. 549, male, Cartagena Lagoon, Sept. 17, 1927.

61. *EREUNETES PUSILLUS* (Linné). Semipalmated Sandpiper. Putilla.

The Semipalmated Sandpiper is a very abundant fall migrant. In the spring it is rather uncommon. It frequents mostly the borders of fresh water lagoons, salt water mudflats, and saltponds, but it is often found at small roadside pools, and even in moist canefields and grassy fields.

On October 9, 1926 I observed a flock of about fifteen swimming on the saltponds at Ensenada where salt is made by the openair evaporation of seawater. At that place the water was about a foot deep. On being scared up the birds flew to land, but soon returned to swimming. They were apparently feeding upon the brine shrimps

(larvae of *Ephydridae*) which abounded there. The stomach of one collected was filled with them.

Localities at which I have observed the species are: Hormigueros, Joyuda, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Anegado Lagoon, Guánica Lagoon, Ensenada and Coamo Springs Reservoir.

Early fall dates are: August 13, 1924 and August 13, 1927 (Cartagena Lagoon).

Late fall dates are: October 20, 1924 (Cartagena Lagoon); October 9, 1926 (Ensenada); October 8, 1927 (Cartagena Lagoon); September 29, 1928 (Faro de Cabo Rojo), and October 12, 1929 (Joyuda).

My earliest positive spring date is April 21, 1928 at Cartagena Lagoon, when three were collected for identification.

Late spring dates are May 15, 1927 (Faro de Cabo Rojo), and May 12, 1928 (Cartagena Lagoon).

Porto Rican specimens now in my collection:
No. 37, female, Cartagena Lagoon, Aug. 20, 1924.
No. 38, female, Ensenada, Oct. 9, 1926.

62. *EREUNETES MAURI* Cabanis. Western Sandpiper. Putilla.

My only Porto Rican record continues to be that of a female collected at Cartagena Lagoon on August 26, 1924.

63. *CROCETHIA ALBA* (Pallas). Sanderling. Putilla.

The Sanderling is a bird which was formerly rare in Porto Rico, but in recent years it has come to be a common winter resident. It is apparently just about as common all through the winter as it is in migrations. It is almost exclusively a bird of the sandbeaches, where it is almost invariably found associated with Ruddy Turnstones, and often with Black-bellied Plovers. It is in its white winter plumage almost all the time it it with us, but occasionally when it first arrives in the fall and just before it leaves in the spring a few molting birds are seen.

The contents of seven stomachs were examined. The food was found to consist exclusively of animal material, of which Crustaceans formed 69.4 per cent, Molluscs 16.4 per cent, and sandworms 4.1 per cent. The stomachs also contained gravel to the extent of 7 per cent of their contents.

I have recorded Sanderlings at Aguada, Mayagüez (common), Joyuda, Boquerón, Faro de Cabo Rojo, Ensenada (common), and Salinas.

Early fall dates are October 9, 1926 (Ensenada); September 21, 1928 and September 11, 1929 (Mayagüez).

Late spring dates are April 4, 1927, April 30, 1929, and May 3, 1930, at Mayagüez.

Porto Rican specimens now in my collection:
No. 47, male, Ensenada, Oct. 9, 1926.
No. 391, female, Mayagüez (Correccional Point), April 4, 1927.
No. 392, male, Mayagüez (Correccional Point), April 4, 1927.
No. 393, female, Mayagüez (Correccional Point), April 4, 1927.
No. 394, female, Mayagüez (Correccional Point), April 4, 1927.
No. 395, male, Mayagüez, (Correccional Point), April 4, 1927.
No. 396, female, Mayagüez (Correccional Point), April 4, 1927.

64. *HIMANTOPUS MEXICANUS* (Müller). Black-necked Stilt. Viuda.

The Stilt is a common breeding bird in Porto Rico, but it is not found here in winter. At Boquerón and El Faro de Cabo Rojo a few are found in the mangrove swamps, and a few at a brackish water pond at Ensenada. Many breed at Cartagena, Anegado and Guánica Lagoons. I have once recorded the species at Puerto Real. Two stomachs were full of comminuted insects and a little gravel. Hemiptera, including water boatmen, figured largely among the insects. Carabid beetles and damselflies were also recognized.

Early spring dates are March 4, 1922 (Anegado Lagoon); March 11, 1924 (Cartagena Lagoon); March 7, 1927 (Anegado Lagoon), and March 9, 1929 (Cartagena Lagoon).

Late fall dates are: October 7, 1924 (Cartagena Lagoon); November 3, 1926 (Puerto Real), and October 27, 1928 (Boquerón). They stay later in the mangrove swamps than at the lagoons.

Porto Rican specimens now in my collection:
No. 49, male, Cartagena Lagoon, May 2, 1924.
No. 50, female, Guánica Lagoon, Oct. 2, 1926.
No. 373, female, Anegado Lagoon, March 7, 1927.

65. *LARUS ATRICILLA* Linné. Laughing Gull. Gaviota.

The Laughing Gull is a common summer visitor to the coasts of Porto Rico, but I doubt if it breeds here. I have recorded the species at Point Borinquen, Aguada, Rincón, Mayagüez, Joyuda, Faro de Cabo Rojo, Cartagena Lagoon (2 records); Cayo Enrique, Ponce and San Juan. It is a common bird in Mayagüez Harbor in the summer months. A few were seen on Desecheo Island on May 7 and 8, 1927, but they were apparently not breeding.

Early spring dates are: March 6, 1924, April 14, 1927, March 31, 1929, and April 15, 1930 (all at Mayagüez).

Late fall dates are: September 13, 1926 (Mayagüez); September 9, 1927 (Mayagüez); September 29, 1928 (one in winter plumage at El Faro de Cabo Rojo); and October 16, 1929 (Joyuda).

66. *GELOCHELIDON NILOTICA ARANEA* (Wilson). Gull-billed Tern. Gaviota.

The Gull-billed Tern is a rather rare summer visitor to Porto Rico, but apparently does not breed here. A few frequented Cartagena Lagoon from May 20 to September 3, 1924 and I took a female on July 9. Three were noted at the same place on August 13, 1927, and on September 3, 1928 I collected a female over some mudflats at Boquerón.

Porto Rican specimen now in my collection:
No. 632, female, Boquerón, Sept. 3, 1928.

67. *STERNA HIRUNDO HIRUNDO* (Linné). Common Tern. Gaviota.

This tern is a common summer visitor to the coasts of Porto Rico, but I have found no evidence of its breeding here.

On September 14, 1928 an injured bird of this species in winter plumage, was found in the hurricane wreckage on the principal street of Mayagüez. It bore band No. 676305 on its leg, showing that it had been banded as a young bird on July 5, 1928 at Chatham, Massachusetts.

Localities at which I have observed Common Terns are: Aguada, Mayagüez, Joyuda, Rat Island, Faro de Cabo Rojo, Ponce, San Juan and Arecibo.

Early spring dates are: January 29, 1927; March 14, 1928; March 1, 1929, and January 24, 1930, all at Mayagüez.

Late fall dates are: October 7, 1926 (Mayagüez); September 20, 1927 (Rat Island); November 16, 1928 (Joyuda); and November 18, 1929 (Joyuda).

Porto Rican specimen now in my collection:
No. 51, female, imm., Mayagüez, Oct. 7, 1926.

68. *STERNA DOUGALLII DOUGALLII* Montagu. Roseate Tern. Gaviota.

On May 9, 1927 I observed a pair two miles west of Rincón Point. On August 15, 1927 about 150 were feeding between Parguera and Cayo Enrique. On September 2, 1928 a large flock of terns, mostly of this species, was seen feeding a few hundred feet offshore near Aguada.

69. *STERNA ANAETHETA RECOGNITA* Mathews. **Bridled Tern.**
Gaviota.

On May 7 and 8, 1927 on Desecheo Island, after dark about fifteen of these birds came in to sleep under a small overhanging cave near our campsite. They made a great deal of noise, and flew back and forth in the dark before going to sleep. One of our party shot two of them by firing at them when they got between him and the moon. Both were males with enlarged testes. None were seen in the daytime.

Porto Rican specimens now in my collection:
No. 405, male, Desecheo, May 8, 1927.
No. 406, male, Desecheo, May 8, 1927.

70. *STERNA FUSCATA FUSCATA* Linné. Sooty Tern. **Gaviota Oscura.**

The Sooty Tern is occasionally seen off the coasts of Porto Rico. A few were seen off the north coast east of Arecibo on June 13, 1927. Off Aguada a few were seen in a mixed flock of terns on September 2, 1928. On October 6, 1929 at the same place of flock of about 500 terns, mostly if not all of this species, were feeding about a quarter of a mile offshore, accompanied by about 150 Boobies.

71 *STERNULA ALBIFRONS ANTILLARUM* (Lesson). Least Tern. Gaviota.

There is a breeding colony of about twenty-five pairs of Least Terns at El Faro de Cabo Rojo, which is the only place on the island at which I have observed this species. They are not found here except during the breeding season. The earliest spring dates I have are April 27, 1924 and April 20, 1929. They begin nesting early in May. On May 14, 1927 a number of their nests were located on some sandy islets in the extensive salt flat lagoon near the lighthouse. At that time egg-laying was taking place. Some of the nests contained two eggs, and others only one, and I collected a female with an egg ready to be laid. The nests were simply small depressions in the sand, in one case with a little debris piled around it. The eggs were light buff colored, so spotted with chocolate as to be difficult to observe against the sand. When the colony was first approached a number of birds arose and scolded with great vigor, but they soon tired of it and left the vicinity. When I visited the colony on May 5, 1928 about fifty birds were in evidence, but no eggs had been laid as yet, although a female collected contained an egg nearly ready to lay. The stomachs of the birds collected contained small silvery fishes.

Porto Rican specimens now in my collection:
No. 407, female, Faro de Cabo Rojo, May 14, 1927.
No. 408, male, Faro de Cabo Rojo, May 15, 1927.
No. 624, male, Faro de Cabo Rojo, May 5, 1928.
No. 625, female, Faro de Cabo Rojo, May 5, 1928.

72. *THALASSEUS MAXIMUS MAXIMUS* (Boddaert). **Royal Tern. Gaviota.**

The Royal Tern is a tolerably common winter resident on the coasts of Porto Rico, and is the only member of its family that is found here regularly at that season. It is possible that a few may spend the summer here, but I have no July nor August records.

One stomach was filled with small fish bones, and another with Crustacean remains.

I have recorded Royal Terns at Aguada, Joyuda, Boquerón, El Faro de Cabo Rojo, and San Juan.

Early fall dates are: September 22, 1926 (Boquerón); September 29, 1928 (Faro de Cabo Rojo); and September 2, 1929 (Aguada).

Late spring dates are: June 13, 1927 (San Juan), and April 16, 1928 (Boquerón).

Porto Rican specimens now in my collection:
No. 236, female, Boquerón, Nov. 6, 1926.
No. 665, female, Faro de Cabo Rojo, Sept. 29, 1928.

73. *THALASSEUS SANDVICENSIS ACUFLAVIDUS* (Cabot). **Cabot's Tern. Gaviota.**

Gabot's Tern is a rare winter visitor to Porto Rico. My only records are of an individual noted from December 4 to 22, 1923 at Cartagena Lagoon.

74. *CHLIDONIAS NIGRA SURINAMENSIS* (Gmelin). **Black Tern. Gaviota Prieta. Gaviota Ceniza. Pitirre de Agua.**

The Black Tern is a fairly common fall migrant at Cartagena Lagoon, and on September 22, 1928 I observed six in winter plumage skimming over a shallow pond of brackish water back of the beach at Ensenada. My earliest record at Cartagena Lagoon is August 20, 1924, and my latest records are October 7, 1924 and September 25, 1926.

Porto Rican specimen now in my collection:
No. 52, female, Cartagena Lagoon, Sept. 3, 1924.

75. *ANOUS STOLIDUS STOLIDUS* (Linné). Noddy. Cervero.

At Desecheo Island on May 8, 1927 one individual was noted on the north shore, and about 200 on the east shore, perched on ledges in the cliffs whence they were loath to fly. Many were building crude nests of sticks and debris on the ledges. Many of these were examined, but none in which eggs had been deposited was noted. The following day about twenty birds were noted fishing and floating on the water about two miles east of the island. My only record for the main island of Porto Rico is of a few birds noted near Cayo Enrique on August 15, 1927.

Porto Rican specimen now in my collection:
No. 404, female, Desecheo Island, May 8, 1927.

76. *COLUMBA LEUCOCEPHALA* Linné. White-crowned Pigeon. Paloma Cabeza Blanca.

At present the White-crowned Pigeon must be considered a rare bird in Porto Rico. Being a lover of the lowland forests it has been largely deprived of its favorite habitat and forced to seek other more favorable regions. Quite a number still breed in the scrubby sand dune forest in the vicinity of Algarrobo and Laguna Tortuguera, but I know of no other place in the island where they can be seen regularly. However, I have the following scattered records from other places: Aguada (four seen on December 1, 1926); San Sebastián (eight seen on April 11, 1927); Añasco (four seen on January 24, 1927); Mayagüez (one seen on October 20, 1926); Monte Grande (one seen on August 17, 1927); Faro de Cabo Rojo (Pair seen on April 27, 1924), and El Yunque (ten seen at elevations of 2500–3000 feet on February 21, 1927).

Porto Rican specimen now in my collection:
No. 398, male, San Sebastián, April 11, 1927.

77. *COLUMBA SQUAMOSA* Bonneterre. Scaled Pigeon. Paloma Turca.

The only place on the main island where I have found Scaled Pigeons is on El Yunque. There they were abundant in the dense forests from 1700 feet almost to the summit, frequenting especially the growths of palms. The species has been reported to me from the region of Maricao and Las Marías. On Desecheo Island one of my students reported to me seeing eight or ten in the hilly interior of the island on May 7, 1927.

78. *COLUMBA INORNATA EXSUL* (Ridgway). **Porto Rican Blue Pigeon.**

On November 13, 1926 I flushed two Blue Pigeons from a Royal Palm tree in a coffee plantation in the hills near Añasco. On taking flight they made a loud clapping noise. The species is very nearly extinct in Porto Rico.

79. *ZENAIDA AURITA ZENAIDA* (Bonaparte). **Zenaida Dove. Tórtola.**

The Zenaida Dove is fairly common and widely distributed in Porto Rico. The birds are usually very wary and difficult to approach. They occur singly or in small flocks. I have found their nests in trees on the semiarid hills of southern Porto Rico, also in the cattails at Cartagena Lagoon. They frequently come to this and other lagoons and streams to drink water and to feed.

Localities at which I have observed Zenaida Doves are: Point Borinquen, San Sebastián, Aguada, Rincón, Mayagüez (common in the vicinity of mangrove swamps by the Caño Corazón and Guanajibo River), Mayagüez–Maricao Road, Joyuda, Boquerón, Faro de Cabo Rojo, Filial Amor, San Germán, Cartagena Lagoon, Lajas, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Guayanilla, Juana Díaz, Coamo Springs, Mameyes, San Lorenzo, Las Piedras, Cidra, Comerío, Algarrobo, Arecibo–Utuado Road, Hatillo, Quebradillas, and Isabela.

A few were observed in the interior of Desecheo Island on May 7 and 8, 1927.

Porto Rican specimen now in my collection:
No. 711, male, Boquerón, Jan. 19, 1929.

80. *CHAEMEPELIA PASSERINA TROCHILA* Bonaparte. **Porto Rican Ground Dove. Rolita. Rola. Tortolita.**

The Ground Dove is an abundant bird in the lowlands of Porto Rico, especially in the drier regions. It is occasionally found at fairly high elevations in the hills. This was the bird that apparently suffered most in the San Felipe hurricane of September 12, 1928. For nearly a year after that scarcely any were seen, but then they rapidly began to reestablish themselves, and at the present writing (1930) are quite common again, although not yet back to pre-hurricane abundance.

On one occasion (April 7, 1928) at Cartagena Lagoon I saw a flock of 150 birds, but usually they occur in pairs or smaller flocks.

The food of the Ground Dove consists practically entirely of small seeds, largely of grasses. In several stomachs that were examined nothing but small seeds were found.

The bills of specimens collected in Porto Rico were dull rose at the base with dusky tips.

I have found but five occupied nests of this species in Porto Rico. A list of the nests follows. (1) Tinaja Hill, south of Cartagena Lagoon, May 28, 1922. The nest was on the ground under the shelter of a small rock and contained two fresh eggs. (2) El Faro de Cabo Rojo, May 15, 1927, built in a small shrub. It contained two young. (3) Mayagüez, May 2, 1928, placed at a height of seven feet in a tree. It contained two eggs. (4) Mayagüez, May 3, 1928, nine feet above the ground on the horizontal branch of a tree, and containing two eggs. The incubating bird did not flush until approached closely. (5) Faro de Cabo Rojo, April 20, 1929, on the ground; really no nest at all, but just some dry grass pressed down to form a slight depression on which the two eggs were laid.

At night Ground Doves roost in thick-foliaged trees.

Localities at which I have observed Ground Doves are: Point Borinquen, Aguadilla, Coloso, Aguada, Rincón, Añasco, Mayagüez, Mayagüez–Maricao Road, Joyuda, Hormigueros, Cabo Rojo, Puerto Real, Guanaquilla, Boquerón, Faro de Cabo Rojo, Monte Grande, Filial Amor, San Germán, Sabana Grande, Cartagena Lagoon, Lajas, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Guayanilla, Peñuelas, Tallaboa, Ponce, Pastillo, Santa Isabel, Juana Díaz, Coamo Springs, Salinas, Jayuya, Maunabo, Yabucoa, Mameyes, Canóvanas, Río Piedras, Martín Peña, San Juan, San Vicente, Vega Alta, Algarrobo, Vega Baja, Guaynabo, Arecibo, Arecibo–Utuado Road, Quebradillas and Isabela.

Porto Rican specimens now in my collection:
No. 55, male, Guánica Lagoon, Oct. 3, 1924.
No. 56, male, Boquerón, Sept. 22, 1926.
No. 57, male, south of Lajas, Sept. 23, 1926.
No. 273, male, Point Borinquen, Dec. 8, 1926.

81. ***OREOPELEIA MONTANA*** **(Linné). Ruddy Quail Dove. Perdiz.**

The Ruddy Quail Dove is now found almost exclusively in coffee plantations, where it is far from common. Apparently the mongoose keeps it from reproducing rapidly. In the forests on El Yunque at elevations below 2000 feet it is somewhat more abundant. I have found it in the coffee plantations near Añasco, Mayagüez and Maricao. A stomach was nearly filled with orange seeds. It also contained a few small black seeds and some white quartz sand.

Porto Rican specimen now in my collection:
No. 727, male, Mayagüez, March 18, 1929.

82. *OREOPELEIA CHRYSIA* (Bonaparte). Key West Quail Dove. Perdiz.

On January 20, 1924 in a coffee plantation in the hills between Mayagüez and Añasco I flushed a bird of this species.

83. *AMAZONA VITTATA VITTATA* (Boddaert). Porto Rican Parrot. Cotorra.

The Parrot is now a very rare and locally distributed bird. So far as I can ascertain it is now found only in the forests of the Sierra Luquillo, where I have not been successful in finding any. One of my students, Mr. Juan Zalduondo, tells me that on June 19, 1927 he observed seven parrots in scattered groups near the base of El Yunque, and that he shot and ate two of them. On December 29, 1927 he visited the Finca La Rosario in the Sierra Luquillo, and found about fifty parrots, of which he shot eight. He preserved one of them as a birdskin and presented it to me.

Porto Rican specimen now in my collection:
No. 592, male, Finca La Rosario, Dec. 29, 1927.

84. *COCCYZUS AMERICANUS AMERICANUS* (Linné). Yellow-billed Cuckoo. Pájaro Bobo.

This Cuckoo is a decidedly rare bird in Porto Rico, though it is possible that it breeds here. I have just two records, one collected in a *ceiba* tree near Cartagena Lagoon on August 13, 1927, and one flushed in some brushy growth at Ensenada on September 22, 1928. The stomach of the bird collected contained twenty-one Lepidopterous larvae, which were identified by Dr. W. T. M. Forbes as Noctuidae of the Catocaline-Erebid series.

Porto Rican specimen now in my collection:
No. 546, male, Cartagena Lagoon, Aug. 13, 1927.

85. *COCCYZUS MINOR TERES* Peters. Mangrove Cuckoo. Pájaro Bobo.

The Mangrove Cuckoo is a widely distributed but rather uncommon bird in Porto Rico. I have found it most commonly in coffee plantations, although I have records from mangrove swamps, dry brushy areas, dense thickets and shade trees.

My records are from the following localities: Añasco, Mayagüez, Maricao, Las Marías, Puerto Real, Cartagena Lagoon, Yauco, Coamo Springs, Aguas Buenas, Vega Alta, Algarrobo, and Quebradillas.

The condition of the gonads of a male collected at Mayagüez on June 24, 1924 and of a female at Añasco, April 22, 1928 indicated that they were breeding at about that time. The stomach of the latter bird contained a cricket, six katydid eggs, and some miscellaneous insect fragments.

Porto Rican specimen now in my collection:
No. 617, female, Añasco, April 22, 1928.

86. *SAUROTHERA VIEILLOTI* Bonaparte. **Porto Rican Lizard Cuckoo. Pájaro Bobo Mayor.**

The Lizard Cuckoo is very common in the dense coffee woods near Maricao, and actually abundant in the brush covered limestone hills east of Vega Alta. It is seen fairly frequently in the coffee woods near Mayagüez and Añasco, and I have seen it near Las Marías, along the Arecibo–Utuado Road, in the forests of El Yunque, and occasionally in the dry brushy regions at Ensenada and near Tallaboa.

Five stomachs contained Anolis lizards (in 3 stomachs) 50.6 per cent; lizard eggs, 2 per cent; a large green Sphingid caterpillar, 6.6 per cent; other caterpillars, 16.1 per cent; a very large walking stick, 14 per cent; centipedes, 6 per cent; a Cerambycid beetle (*Solenoptera thomae*), 2.8 per cent; and miscellaneous animal matter, 1.9 per cent. A piece of white quartz gravel was found in one stomach.

Porto Rican specimens now in my collection:
No. 258, male, Montoso Mt., Nóv. 24, 1926.
No. 356, male, Añasco, Jan. 24, 1927.
No. 594, male, Maricao, Feb. 4, 1928.
No. 742, female, Vega Alta, March 9, 1930.

87. *CROTOPHAGA ANI* (Linné). Ani. Judío.

The Ani is a common resident bird in Porto Rico. It is found in most parts of the island where there is open country, although I have several times observed it in the woods.

On January 4, 1930 near Mayagüez a flock of eight birds was flying around from tree to tree in some coffee woods. At frequent intervals one of the birds would vibrate its outspread wings and emit a medley of squeaks and squawks, making as much noise as a large flock of grackles. The whole flock seemed very much excited. Apparently these actions had something to do with mating, although I did not see any actual mating take place.

In February 1922 a nest placed high in a large tree at Mayagüez was occupied by a flock of Anis. It was of bulky construction, tapering almost to a point at the bottom. The position of the nest was so inaccesible that I was unable to make any detailed observations of the nesting activities. I have already reported a nest which I observed under construction at Cartagena Lagoon in December, 1923.

Anis have been observed by me at Point Borinquen, Aguadilla, San Sebastián, Rincón, Añasco, Mayagüez, Hormigueros, Joyuda, Cabo Rojo, Puerto Real, Boquerón, Faro de Cabo Rojo, Filial Amor, Monte Grande, San Germán, Sabana Grande, Cartagena Lagoon, Lajas, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Guayanilla, Tallaboa, Peñuelas, Jayuya, Ponce, Pastillo, Santa Isabel, Guayabal Reservoir, Villalba, Juana Díaz, Coamo, Coamo Springs, Salinas, Cidra, Juncos, San Lorenzo, Las Piedras, El Yunque (at low altitudes), Martín Peña, Dorado, Toa Baja, Algarrobo, Manatí, Barceloneta, Garrochales, Arecibo, Arecibo–Utuado Road, Camuy and Quebradillas.

Porto Rican specimens now in my collection:
No. 61, male, Cartagena Lagoon, Sept. 30, 1924.
No. 227, female, Cartagena Lagoon, Oct. 30, 1926.
No. 618, female, Mayagüez, April 24, 1928.

88. *GYMNASIO NUDIPES NUDIPES* (Daudin). Bare-legged Owl. Múcaro.

The Bare-legged Owl is a common resident in the wooded regions of Porto Rico, where its trilling song, somewhat higher pitched and more rapidly uttered than that of the Screech Owl, is a conspicuous sound of the night. This song is heard at all times of the year, although somewhat less frequently in the winter than during the spring and summer months. This little owl is strictly nocturnal in its habits. I have never come across one of them in the daytime, nor have I ever heard its song before nightfall. On a few occasions I have heard the birds continue singing for about half an hour after sunrise. They are more vociferous on moonlight than on dark nights. Sometimes at night owls can be seen flying across the road in front of automobile headlights, with a straight, direct flight, evidently in pursuit of some insect. I have found it impossible to jack these owls with a flashlight.

A stomach from Mayagüez was filled with insects, among which a large grasshopper and a weevil (*Diaprepes abbreviatus*) were recognized.

I have seen or heard múcaros at the following localities: Añasco (common); Mayagüez (common); Maricao (common); Montoso Mountain (common); Hormigueros, San Germán, Cartagena Lagoon (reported), Coamo Springs, Cidra, El Yunque, Algarrobo, Arecibo–Utuado Road, Adjuntas, Utuado–Ponce Road. They are probably common in all the wooded hilly parts of the interior of the island.

Porto Rican specimens now in my collection:

No. 713, male, Mayagüez, Jan. 27, 1929.

No. 714, female, Mayagüez, Oct. 3, 1924.

89. *ASIO DOMINGUENSIS PORTORICENSIS* Ridgway. Porto Rican Short-eared Owl. Pájaro Cuco. Múcaro Real.' Múcaro de Sabana.

On September 29, 1926 while I was observing birds at the edge of Anegado Lagoon one of these owls flew down from a hill and alighted in some marsh grass growing in water about two feet deep. I flushed it two or three times afterwards, and succeeded in photographing it before collecting it. Each time it flew a crowd of small birds, mainly *Holoquiscalus*, gathered around it to scold. On shooting the owl I merely winged it, and brought it back to Mayagüez alive. At first it was very fierce, and attacked me with bill and claws, but it soon weakened and died. Its stomach contained small bird feathers, some white, others black at the base and reddish brown at the tip.

Mr. Wm. Burlingame reports seeing and almost catching a short-eared owl at Algarrobo on May 9, 1930.

Porto Rican specimen now in my collection:

No. 63, male, Anegado Lagoon, Sept. 29, 1926.

90. *ANTROSTOMUS CAROLINENSIS* (Gmelin). Chuck-will's-widow.

Although I have never found this species in Porto Rico, one of my students reports seeing it on several occasions in winter at Lares. He described the bird and its habits very accurately, and picked it out immediately from among the other Caprimulgidae in the colored plates I have at hand, so I feel no hesitation in listing these records.

91. *CHORDEILES MINOR GUNDLACHII* Lawrence. Cuban Nighthawk.

The Cuban Nighthawk is a rare summer visitor in Porto Rico, and probably breeds. I have never succeeded in collecting a specimen, so some of my records may refer to the Bahaman Nighthawk.

My records are as follows: Mayagüez (one on May 2, 1928, and a flock of 10 on May 20, 1930); San Germán (one on April 27, 1929); Faro de Cabo Rojo (several on May 14, 1927); Cartagena

Lagoon (one on each of the following dates: May 27, June 7 and June 28, 1924); Ensenada (one on August 16, 1927); Guánica (two on September 6, 1929); Algarrobo (one heard just before dawn on February 22, 1928, and five seen by Miss N. G. Spaulding on April 24, 1930).

These birds are usually seen flying around on cloudy afternoons, or after heavy afternoon showers.

92. ***NEPHOECETES NIGER NIGER*** **(Gmelin). Antillean Black Swift. Golondrina.**

The Black Swift is seen only in summer in Porto Rico, where it probably breeds. My records run from the last of March to the last of July. Usually only small flocks are seen, often in company with swallows. On one occasion on a showery afternoon (May 13, 1928) about 125 swifts were flying over a river and bordering coffee woods near Mayagüez. On another occasion (March 29, 1924) forty were flying over the then-dry Anegado Lagoon. On two occasions (April 30, 1928 at Mayagüez and April 27, 1929 at San Germán) I have seen as many as twenty together, but these large assemblages are unusual. When these swifts fly low a soft *"tchip, tchip"* call note may be heard.

I have the following records for the species: Mayagüez (March 31, 1922 and several successive dates; May 24, 28, 31, July 12 and 28, 1924; May 10, 11, 23, 24, 26 and 29, 1927; April 4, 23, 30, May 13 and 17, 1928; April 21, 25, May 9 and 19, 1929, and May 20, 1930); San Germán (April 27, 1929); Filial Amor (May 16, 1924); Guanaquilla (June 28, 1924), and Anegado Lagoon (March 29, 1924).

93. ***CHLOROSTILBON MAUGAEUS*** **(Audebert and Vieillot). Porto Rican Emerald. Fork-tailed Hummingbird. Zumbadorcito.**

The Fork-tailed Hummingbird is a fairly common resident bird in Porto Rico, found in many types of localities, but nevertheless somewhat local in its distribution and irregular in its times of occurrence at any one particular locality. At one time or another it is found everywhere from the high rain forests of El Yunque to the driest regions on the south coast, and even occasionally in the mangrove swamps.

It breeds quite commonly in the brushy, sandy region near Algarrobo, where Miss Nina G. Spaulding has found their nests, and on November 17, 1929 observed parents feeding young just out of the nest.

On November 8, 1926 I observed and photographed a nest in a coffee plantation near Maricao. The nest was placed seventeen inches above the ground in a coffee seedling in a seedbed. It was attached to the vertical stem. The nest was made of banana and other plant fibers, and was lined with fine plant down. Four small pieces of lichen were stuck on the outside. It contained one young with a little fuzzy down on its back and its eyes not yet open. It also contained fragments of a broken egg. When a friend of mine saw the nest on October 30 it contained two eggs. On my visit, as previously, the female was very tame and permitted herself to be stroked on the back without leaving the nest, merely spreading her wings on being stroked. In fact I had to actually lift her off the nest in order to see the young, and then she would return within a few seconds. Once I picked her up to examine the colors of her soft parts, and then let her go. She flew away, but returned to the nest within a minute. The foreman of the coffee pickers, who were at work near the nest, said that if a nest is found when it has eggs one can dig the plant up by the roots, and carry plant and nest into a house, and that the female will stay on the nest all the time, and continue to incubate the eggs in the house. The iris of the female was very dark brown, and the bill, legs and feet black. The skin of the young was black, sparsely covered with reddish brown down. Its bill was dull orange.

On April 25, 1927 at Consomo I discovered another nest with young. It was attached to a slender drooping twig of a tree, near the bases of the terminal leaves, fifteen feet above a brook, in a quite inaccessible position.

These diminutive hummers are very pugnacious, and do not hesitate to attack birds very much larger than themselves, even Sparrow Hawks.

I have observed the species at the following localities: Aguadilla, Añasco, Mayagüez, Maricao, Montoso Mountain (up to the very summit), Consomo, Las Marías, San Sebastián, Joyuda, Cabo Rojo, Puerto Real, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Anegado Lagoon, Ensenada, Yauco, Guayanilla, Tallaboa, Coamo Springs, Guayama–Cayey Road, El Yunque (up to 3,000 feet), and Algarrobo.

Porto Rican specimens now in my collection:

No. 65, male, Mayagüez, June 30, 1924.

No. 235, male, Boquerón, Nov. 6, 1926.

No. 376, female, Consomo, March 11, 1927.

No. 608, male, Mayagüez, April 14, 1928.

94. *ANTHRACOTHORAX VIRIDIS* (Audebert and Vieillot).
Green Mango. Zumbador.

The Green Mango is a common resident in Porto Rico. It is particularly abundant in the interior coffee woods, but at certain places and seasons it is not at all uncommon on the coast. Its presence at the coast seems to depend upon the blossoming of certain flowers. At Puerto Real, for example, it fairly swarms in November when some vines growing in a brushy region back of the beach are in blossom, but in December, when these blossoms are gone, not a hummer is to be seen in this region.

Early in the morning, while the woods are still dripping with the dews of the night before, these hummers love to perch on some bare twig to sun themselves and preen their feathers.

Localities at which I have observed Green Mangos are: Añasco, Mayagüez, Consomo, Puerto Real, Monte Grande, Cartagena Lagoon and Yauco.

A stomach from Mayagüez contained two spiders (45 per cent) and comminuted insects (55 per cent). One from Puerto Real contained a yellow flower spider.

Porto Rican specimens now in my collection:
No. 222, female, Mayagüez–Maricao Road, Oct. 23, 1926.
No. 361, male, Mayagüez, Feb. 18, 1927.
No. 607, male, Mayagüez, April 14, 1928.
No. 610, female, Mayagüez, April 15, 1928.
No. 662, male, Puerto Real, Nov. 6, 1928.
No. 716, female, Monte Grande, Feb. 7, 1929.

95. *ANTHRACOTHORAX AURULENTUS* (Audebert and Vieillot).
Porto Rican Mango. Zumbador.

The Porto Rican Mango is the common hummer of the coastal regions of Porto Rico. It is found to some extent in the hills, but not at very high altitudes nor in the dense woods.

On April 1, 1922 at Anegado Lagoon I found a newly completed nest which I have already described. On May 14, 1927 at El Faro de Cabo Rojo I discovered another nest. It was a compact affair made of white, cottony plant fibers, and placed in a mangrove tree at a height of six feet from the ground at a point where some twigs gave it side support. It contained two newly hatched young and some pieces of broken eggshell. The female was very solicitous for the welfare of her offspring, and whirred almost into my face while I

was examining them. On March 30, 1929 at Cartagena Lagoon I captured a young bird just out of the nest, but as yet unable to fly.

At Puerto Real early in November these birds, in company with the Green Mangos, fairly swarm at the blossom of an unidentified vine. As with most hummers, the local abundance of the species at different times of the year depends upon the blossoming period of certain favored plants.

Two stomachs contained nothing but small insects and spiders.

Localities at which I have observed the species are: Añasco, Mayagüez, Mayagüez-Maricao Road, Joyuda, Puerto Real, Sabana Grande, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Parguera, Cayo Enrique, Anegado Lagoon, Ensenada, Yauco, Juana Díaz, Coamo Springs, Fajardo, Río Piedras, Algarrobo, Camuy and Quebradillas.

Porto Rican specimens now in my collection:
No. 71, male, Guánica Lagoon, Oct. 3, 1924.
No. 72, male, Guánica Lagoon, Oct. 2, 1926.
No. 243, male, imm. Añasco, Nov. 13, 1926.
No. 619, male, imm. Joyuda, April 27, 1928.
No. 631, male, Anegado Lagoon, Sept. 1, 1928.
No. 735, male, Cartagena Lagoon, March 9, 1929.

96. *STREPTOCERYLE ALCYON ALCYON* (Linné). Belted Kingfisher. Pájaro del Rey. Martín Pescador.

The Kingfisher is a common winter resident in Porto Rico. It is most abundant along the coast, but is sometimes found along streams well into the mountainous interior of the island. It is also found at the fresh water lagoons, but not so commonly as along the coast.

Two birds collected at Mayagüez had eaten nothing but fish, while two small gray crabs were found in the stomach of one collected at Joyuda.

Early fall dates are: October 14, 1921 (San Juan); September 23, 1924 (Cartagena Lagoon); September 22, 1926 (Boquerón); September 25, 1927 (Mayagüez); September 29, 1928 (Faro de Cabo Rojo), and September 20, 1929 (Joyuda).

Late spring dates are: April 11, 1922 (Quebradillas); April 18, 1927 (Mayagüez); April 21, 1928 (Mayagüez); May 1, 1929 (Mayagüez), and April 24, 1930 (Joyuda).

Localities at which I have observed the species are: Aguada, Rincón, Añasco, Mayagüez, Maricao, mountains five miles east of Maricao, Consomo, Cabo Rojo, San Germán, Joyuda, Rat Island, Puerto

Real, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Anegado Lagoon, Ensenada, Peñuelas, Tallaboa, Ponce, Adjuntas, Utuado, Naranjito, Salinas, Coamo, Coamo Springs, Central Aguirre, Maunabo, Playa de Naguabo, Santurce, San Juan, Algarrobo, Arecibo, and Quebradillas.

Porto Rican specimens now in my collection:
No. 84, male, Mayagüez, Oct. 7, 1926.
No. 260, male, imm., Joyuda, Nov. 27, 1926.

97. *TODUS MEXICANUS* Lesson. Porto Rican Tody. San Pedrito. Medio Peso.

The Tody is a common resident in the wooded regions of Porto Rico, and is even found to some extent in the brushy areas in the dry south coastal region. It is most abundant in the coffee woods. In regions where the Tody is common one frequently sees its nesting holes dug in the clay banks bordering streams or in other places.

On October 12, 1928 at Consomo about ten Todies were feasting upon a swarm of mayflies which had just emerged along a small stream.

The contents of five stomachs were examined, and 99.4 per cent animal matter and 0.6 per cent vegetable matter was found. The latter consisted of a seed in one stomach. Spiders formed 14.4 per cent; earwigs 1.6 per cent; Coleoptera 31.4 per cent (including bark beetles 12 per cent, and weevils 1.6 per cent); Lepidopterous larvae 19.7 per cent, and winged ants 1.4 per cent. The rest of the animal matter consisted of comminuted insects. One bird had eaten a feather, probably its own.

The ordinary note is a rather harsh *check,* slightly suggestive of that of the Ruby-crowned Kinglet, but a little longer drawn out and less abrupt.

Localities at which I have observed Todies are: San Sebastián, Aguada, Añasco, Mayagüez, Las Marías, Consomo, Maricao, Montoso Mountain, San Germán, Monte Grande, Cartagena Lagoon, Parguera, Anegado Lagoon, Yauco, Yauco–Lares Road, Adjuntas, Utuado, Jayuya, Orocovis, Corozal–Orocovis Road, Cidra, Guayanilla, Tallaboa, Villalba–Ciales Road, Coamo Springs, Guayama, El Yunque, Aguas Buenas, Vega Alta and Quebradillas.

Porto Rican specimens now in my collection:
No. 81, female, Mayagüez, Dec. 23, 1923.
No. 82, female, Yauco, Oct. 6, 1926.
No. 83, female, Mayagüez, Oct. 20, 1926.

No. 257, male? Montoso Mountain, Nov. 24, 1926.
No. 613, male, Las Marías, April 6, 1928.
No. 719, female, Coamo Springs, Feb. 10, 1929.

98. ***MELANERPES PORTORICENSIS*** **(Daudin). Porto Rican Woodpecker. Carpintero.**

The Woodpecker is common wherever there is sufficient cover. The female has the red on the under surface of the body much less extensive than the male. The nesting holes are excavated in cocoanut palms, almendros or other trees, usually at heights of twenty feet or more above the ground. The birds begin occupying the nest holes in January, but probably do not deposit eggs until February. On March 4, 1927 a boy climbed up to a nest hole high in a cocoanut palm, cut the hole open with a *machete,* and captured the incubating bird on the nest, which contained four white eggs. He presented the bird and the eggs to me. On dissection the bird proved to be a male.

Four stomachs were examined, and found to contain 65 per cent vegetable and 35 per cent animal matter. The former consisted of fruits (*jobo,* quenep, and some small unidentified fruits). The animal matter was composed entirely of insects, among which cockroaches 12.5 per cent, Coleopterous larvae 10 per cent, and weevils 2.5 per cent were recognized.

Localities at which I have observed Porto Rican Woodpeckers are: San Sebastián, Aguada, Añasco, Mayagüez (common), Las Marías (common), Consomo (common), Maricao (common), Montoso Mountain (common), Joyuda (rare), Puerto Real (common in cocoanut palms), south of Boquerón, San Germán, Monte Grande, Parguera (rare), Anegado Lagoon (rare), Ensenada (rare), Yauco, Villalba–Ciales Road (common), Orocovis, Coamo Springs (common), San Lorenzo, El Yunque, Vega Alta, Algarrobo, Arecibo–Utuado Road, and Quebradillas.

Porto Rican specimens now in my collection:
No. 90, male, Mayagüez, Sept. 25, 1924.
No. 91, male, Mayagüez, Oct. 16, 1926.
No. 371, male, Mayagüez, March 4, 1927.
No. 737, female, Mayagüez, March 16, 1929.
No. 738, female, Maricao, March 16, 1929.

99. ***TYRANNUS DOMINICENSIS DOMINICENSIS*** **(Gmelin). Gray Kingbird. Pitirre.**

The Gray Kingbird is an abundant resident in Porto Rico, particularly in the coastal regions. It appears to be somewhat more

abundant in the winter than in the summer, also to have a greater tendency to congregate, although it can never be said to form large flocks. I believe it is possible that some of the birds which breed in Florida and Cuba may winter here.

The Gray Kingbird is one of the first birds to awaken in the morning, and on moonlight nights I have heard it begin calling two hours before dawn.

The stomach of a bird collected contained three medium-sized brown cockroaches. In the field I observed a Pitirre capture a large red winged wasp (*Pepsis rubra*). It carefully removed the wasp's wings before swallowing it.

Localities at which I have observed this species are: Point Borinquen, Aguadilla, San Sebastián, Coloso, Aguada, Rincón, Añasco, Mayagüez, Joyuda, Puerto Real, Hormigueros, Cabo Rojo, Guanaquilla, San Germán, Sabana Grande, Monte Grande, Filial Amor, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Guayanilla, Tallaboa, Peñuelas, Ponce, Jayuya, Fortuna, Pastillo, Santa Isabel, Juana Díaz, Guayabal Reservoir, Villalba, Coamo, Coamo Springs, Coamo Springs Reservoir, Patillas, Humacao, Naguabo, Fajardo, San Lorenzo, Las Piedras, Aibonito, El Yunque (rare above 1,000 feet), Mameyes, Canóvanas, Loíza, Trujillo Alto, Río Grande, Carolina, Río Piedras, Martín Peña, Bayamón, Caguas, Cidra, Aguas Buenas, Gurabo, Juncos, Vega Alta, Vega Baja, Algarrobo, Manatí, Arecibo, Arecibo–Utuado Road, Utuado, Ciales, Camuy, Quebradillas and Isabela.

Porto Rican specimens now in my collection:
No. 92, female, Cartagena Lagoon, Sept. 23, 1924.
No. 265, male, Aguada, Dec. 1, 1926.

100. *TOLMARCHUS TAYLORI* (Sclater). Porto Rican Petchary. Clérigo.

The Petchary is a common resident bird in Porto Rico, where it is most abundant in the coffee woods, but it is found at times in almost any region where there is cover, even in the mangrove swamps.

Three stomachs contained nothing but insects. One contained a large Sphinx moth and a weevil (*Diaprepes abbreviatus*). Another had eaten a male carpenter bee (*Xylocopa brasilianorum*). The third stomach contained two wasps (*Polistes crinitus*) and a small black Sphecid wasp.

I have observed Petcharies at San Sebastián, Aguada, Rincón,

Añasco, Mayagüez, Maricao, Montoso Mountain, Consomo, Joyuda, Cabo Rojo, Puerto Real, Boquerón, Cartagena Lagoon, Parguera, Anegado Lagoon, Yauco, Tallaboa, Peñuelas, Guayabal Reservoir, Santa Isabel, Coamo Springs, Aibonito, San Lorenzo, Las Piedras, Cidra, El Yunque, Mameyes, Algarrobo, Manatí, Ciales–Jayuya Road. Utuado, Quebradillas and Isabela.

Porto Rican specimens now in my collection:

No. 95, female, Mameyes, Oct. 12, 1926.

No. 223, female, Mayagüez–Maricao Road, Oct. 23, 1926.

No. 231, male, Mayagüez, Nov. 1, 1926.

No. 354, male, Mayagüez, Jan. 17, 1927.

101. *MYIARCHUS ANTILLARUM* (Bryant). Porto Rican Flycatcher. Jüi.

This flycatcher was fairly common when I first arrived on the island, but in the past few years it has become a decidedly rare bird, whether from scarcity of nesting sites or from other unknown causes it would be difficult to state. It is found chiefly in wooded or brushy areas where it can keep under cover. It is occasionally found in mangrove swamps. It captures its prey of insects on the wing.

Four stomachs contained 53.3 per cent of animal matter and 46.7 per cent of vegetable matter. The latter consisted of small fruits, including *Cordia* sp. Turning to the animal matter, Coleoptera formed 25.1 per cent, and included *Lachnopus curvipes,* other weevils, and Buprestid beetles, *Chrysobothris wolcotti.* Damselflies and Lepidopterous larvae each formed 12.5 per cent.

Localities at which I have observed this species are: Aguada, Añasco, Mayagüez, Maricao, Joyuda, Cartagena Lagoon, Parguera, Anegado Lagoon, Guánica Lagoon, Yauco, Ponce, Villalba–Ciales Road, Juana Díaz, Coamo Springs, El Yunque (up to 3,000 feet), and Algarrobo.

Porto Rican specimens now in my collection:

No. 103, male, Yauco, Oct. 6, 1926.

No. 104, male, Mayagüez, Oct. 20, 1926.

No. 251, female, Hills south of Anegado Lagoon, Nov. 20, 1926.

102. *BLACICUS BLANCOI* Cabanis. Porto Rican Pewee. Bobito.

The Pewee is another bird which, like the Myiarchus, has become very scarce in Porto Rico in recent years. The decrease of neither can scarcely be attributed to the hurricane of 1928, as it was very noticeable before that time. The Pewee is primarily a bird of the

coffee woods, and it is confined to central and western Porto Rico. My easternmost record is Coamo Springs, and I never saw it during my frequent visits to that place until September 8, 1929. Since that time a pair has frequented a wooded ravine back of the hotel.

The contents of four stomachs was found to be exclusively insects. Among them the following items were recognized: An earwig (*Phaulex albipes*), two Cicadas (*Proarno hilaris*) in one stomach, a tree hopper, and three weevils (*Chalcodermus pupillatus*). Coleoptera and Diptera figured very largely in the stomach contents.

I used to find the Pewee common at Añasco, Mayagüez, Las Marías, Consomo and Maricao. Other localities at which I have found it more rarely are Joyuda and Puerto Real (in the mangrove swamps); Faro de Cabo Rojo, Ensenada and south of Anegado Lagoon (on dry brushy or sparsely wooded hills), and at Coamo Springs.

Porto Rican specimens now in my collection:
No. 106, female, Mayagüez, June 24, 1924.
No. 224, female, Mayagüez–Maricao Road, Oct. 23, 1926.
No. 248, female, Consomo, Nov. 17, 1926.
No. 267, male, Mayagüez, Dec. 3, 1926.

103. *RIPARIA RIPARIA RIPARIA* (Linné). Bank Swallow. Golondrina.

The Bank Swallow is tolerably common in Porto Rico in the spring migration, frequenting the vicinity of water. I have observed from five to fifty at Cartagena Lagoon on April 8, 1922, from February 19 to April 30, 1924, on March 28, 1927, from February 11 to April 25, 1928, and on February 8, March 6, and May 10, 1930. At Anegado Lagoon I observed about thirty on March 4 and April 1, 1922, and a few at Laguna Tortuguera on March 20 and 22, 1927. I have in my collection a mummified specimen which I found dead, impaled on a barbed wire fence, at Cartagena Lagoon.

Porto Rican specimen now in my collection:
No. 605, sex?, mummy, Cartagena Lagoon, April 7, 1928.

104. *HIRUNDO ERYTHROGASTER* Boddaert. Barn Swallow. Golondrina.

The Barn Swallow is fairly common in migration, and a rare and irregular winter resident in Porto Rico. Until this past winter I never observed any at that season. From November 29 to December 1, 1929 I noted about fifteen frequenting the vicinity of Coamo

Springs Reservoir, and on January 10, 1930 about ten were skimming over a dry parched field near Yauco.

While with us the Barn Swallow is usually found at the lagoons, but occasionally along rivers, or even over dry fields. The only localities at which I have observed the species are Mayagüez, San Germán, Cartagena Lagoon, Anegado Lagoon, Yauco, and Coamo Springs Reservoir.

Early fall dates are: August 26, 1924 (Cartagena Lagoon), and September 11, 1927 (Mayagüez).

Late fall records are: September 30, 1924 (Cartagena Lagoon); October 9, 1926 (San Germán), and September 22, 1928 (Cartagena Lagoon).

Early spring dates are: March 1, 1924, March 28, 1927, and February 8, 1930 (all at Cartagena Lagoon).

Late spring dates are May 14, 1922, May 23, 1924, April 25, 1928, April 13, 1929, and May 10, 1930, (all at Cartagena Lagoon).

105. *PETROCHELIDON FULVA POECILOMA* (Gosse). Jamaican Cliff Swallow. Golondrina de Cuevas.

The Cliff Swallow is an abundant resident. During the breeding season it is restricted to those regions where it finds suitable nesting sites, but during the rest of the year wanders over the entire island. The nesting season is from April to June.

A stomach from El Faro de Cabo Rojo was filled with insects, of which nymphs of aquatic Hemiptera (*Zaitha anura*) formed 80 per cent, and Tenebrionid beetles 20 per cent.

In the fall and winter these swallows often appear in large flocks in localities distant from their nesting sites.

Localities at which I have observed this species are: Coloso, Aguada, Rincón, Añasco, Mayagüez, Consomo, Maricao, Hormigueros, San Germán, Filial Amor, Cabo Rojo, Sabana Grande, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Tallaboa, Ponce, Juana Díaz, Coamo, Coamo Springs, Ceiba, Aibonito, Río Piedras, Santurce, San Juan, Bayamón, Vega Alta, Algarrobo, Manatí, Arecibo, Utuado and Quebradillas.

Porto Rican specimens now in my collection:

No. 107, female, Cartagena Lagoon, Aug. 13, 1924.

No. 108, male, Cartagena Lagoon, Aug. 13, 1924.

No. 664, male, Faro de Cabo Rojo, Sept. 29, 1928.

106. *PROGNE DOMINICENSIS* (Gmelin). Caribbean Martin. Golondrina de Iglesias.

The Martin is a common summer resident and breeder in Porto Rico, but is absent during the winter. It nests in ventilating holes and belfries of buildings, and occasionally in holes in trees. It is most abundant in the towns, but is occasionally found nesting far from towns.

I have observed Caribbean Martins at Aguada, Rincón, Añasco, Mayagüez, Maricao, Joyuda, Puerto Real, Cabo Rojo, San Germán, Sabana Grande, Boquerón, Cartagena Lagoon, Yauco, Ponce, Santa Isabel, Fajardo, Santurce, San Juan, Barranquitas, Laguna Rica (near Algarrobo), Quebradillas and Isabela.

Early spring dates are January 6, 1922 at Boquerón, and February 19, 1924, January 23, 1927, January 24, 1928, January 14, 1929, and January 27, 1930 at Mayagüez.

Late fall dates are: September 9, 1924 (Mayagüez); September 25, 1926 (Cartagena Lagoon); September 11, 1927 (Mayagüez); September 14, 1928 (Mayagüez), and September 6, 1929 (San Germán).

107. *CORVUS LEUCOGNAPHALUS* Daudin. Porto Rican Crow. Cuervo.

On February 21, 1927 I heard a Crow at an elevation of 3,200 feet on El Yunque. That is my only experience with the species in life in this island. However, on December 28, 1927 at Finca La Rosario in the Sierra Luquillo one of my students, Mr. Juan Zalduondo, saw over a hundred Crows, and collected one for me.

Porto Rican specimen now in my collection:
No. 591, female, Finca La Rosario, Dec. 28, 1927.

108. *MIMUS POLYGLOTTOS ORPHEUS* (Linné). Jamaican Mockingbird. Ruiseñor.

The Mockingbird is an abundant resident in Porto Rico. It prefers open lowland country, and is especially abundant in the dry south coastal region.

Mockingbirds breed most commonly in the spring, but on November 20, 1926 at Ensenada I collected a female containing an egg nearly ready to be deposited. They sing to some extent throughout the year, but most commonly from January to September.

Two stomachs contained exclusively small fruits, Jicaco and others.

Localities at which I have observed Mockingbirds are: Point Borinquen, Aguadilla, San Sebastián, Aguadilla, Coloso, Aguada, Rin-

cón, Añasco, Mayagüez, Joyuda, Puerto Real, Cabo Rojo, Hormigueros, San Germán, Filial Amor, Monte Grande, Guanaquilla, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Guayanilla, Tallaboa, Peñuelas, Ponce, Pastillo, Juana Díaz, Guayabal Reservoir, Villalba, Santa Isabel, Coamo Springs, Salinas, Guayama, Humacao, Las Piedras, Juncos, Mameyes, El Yunque (up to 1,700 feet), Canóvanas, Río Piedras, Bayamón, Vega Alta, San Vicente, Algarrobo, Laguna Tortuguera, Manatí, Garrochales, Arecibo, Morovis, Arecibo–Utuado Road, Camuy, Quebradillas and Isabela.

Porto Rican specimens now in my collection:
No. 122, female, Cartagena Lagoon, Sept. 30, 1924.
No. 253, female, Ensenada, Nov. 20, 1926.

109. *MARGAROPS FUSCATUS FUSCATUS* (Vieillot). Pearly Eyed Thrasher. Zorzal Pardo. Pío-Juan.

This Thrasher is a species which is becoming more abundant and more generally distributed in Porto Rico. Formerly it was primarily a bird of the dry brush-covered hills of the south coast. In recent years it has become common at the west end of the island, in the regions of Rincón, Mayagüez and Joyuda, and I see it much more frequently than formerly in other parts of the island.

Its song is very similar, but somewhat inferior to that of the Thrush. It is not quite so loud nor so rich, though it has a greater variety of notes, and the songs of the two birds are at times distinguishable only with difficulty. The song of Margarops may be heard to some extent at any season of the year, but most frequently from January to September.

Margarops is the only Passerine bird found on Desecheo Island, where I found it rather scarce at the time of my visit in May, 1927. In Porto Rico I have noted it at San Sebastián, Aguada, Rincón, Añasco, Mayagüez, Joyuda, Las Marías, Cabo Rojo, Monte Grande (common), Faro de Cabo Rojo, Cartagena Lagoon (rare), hills south of Guánica Lagoon, Yauco, Coamo Springs, Guayama, Naguabo, El Yunque (up to 2,000 feet), Trujillo Alto, Arecibo and Quebradillas.

On April 26, 1928 I discovered a nest at Joyuda. It was a rather bulky affair built mainly of dry leaves, and placed in the small branches near the top of a tree twenty feet above the ground. The well fledged young flew out of the nest when I approached it too closely.

Porto Rican specimen now in my collection:
No. 124, female, Monte Grande, Oct. 6, 1926.

110. *MIMOCICHLA ARDOSIACEA PORTORICENSIS* (Bryant). Porto Rican Thrush. Zorzal. Zorzal de Patas Coloradas.

The Thrush is a common resident in Porto Rico, very common in the coffee woods, and fairly common in other regions where there is sufficient cover.

On September 10, 1927 at Mayagüez I found a young bird scarcely out of the nest, and on May 2, 1928, also at Mayagüez, some boys brought me two well fledged young nearly ready to fly which they said they had taken from a nest high up in a tree. On March 30, 1924 I found a nest with eggs (which I have already described), and I have observed birds carrying nesting material early in February. A female collected at San Sebastián on April 11, 1927 contained eggs ready for the shell.

The song of the Porto Rican Thrush is quite similar to that of the American Robin, but is less varied and the tones are not so rich. On the morning after the hurricane of September 13, 1928 the only bird that could be heard amid the scene of desolation was a Thrush singing from the leafless trees at daybreak before the hurricane winds had entirely ceased.

A stomach contained a small fruit, and another a Long-horned Grasshopper (*Neoconocephalus triops*), and some tree frog bones (*Eleutherodactylus* sp).

Localities at which I have observed Porto Rican Thrushes are: Aguadilla, San Sebastián, Añasco, Mayagüez, Maricao, Consomo, Las Marías, Joyuda, Puerto Real, Cabo Rojo, San Germán, Monte Grande, Guanaquilla, Cartagena Lagoon, Lajas, Lares–Yauco Road, Yauco, Guayanilla, Tallaboa, Coamo Springs, Humacao, Mameyes, El Yunque, Aguas Buenas, Caguas, Río Piedras, Bayamón, Toa Alta, Algarrobo, Arecibo–Utuado Road, and Quebradillas.

Porto Rican specimens now in my collection:

No. 125, male, Yauco–Lares Road, Oct. 6, 1926.
No. 397, female, San Sebastián, April 11, 1927.

111. *VIREO LATIMERI* Baird. Latimer's Vireo. Bien-te-veo.

Latimer's Vireo is a common bird, but of somewhat local occurrence in Porto Rico. It is most abundant in the dry brushy country of the south coastal region, but it is almost equally common on the brush-covered hills of the north side of the island. It is also found to some extent in the coffee woods at the western end of the island. Its song has been very aptly described by Miss Nina G. Spaulding as

che-wichy-blur. In Spanish it is rendered as *Bien-te-veo.* The song has some variations.

I have observed Latimer's Vireos in the coffee woods at Añasco, Mayagüez, Las Marías, Consomo, Maricao and Montoso Mountain; on the south coast at El Faro de Cabo Rojo, Cartagena Lagoon, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Guayanilla, Tallaboa and Coamo Springs; and on the north side of the island at Vega Alta, Algarrobo, Arecibo–Utuado Road, Quebradillas and San Sebastián.

Two stomachs contained 72.5 per cent animal matter and 17.5 per cent vegetable matter. The latter consisted of seeds and drupes, the former of insects and their eggs. A walking stick (30 per cent), weevils (14 per cent), an Elaterid beetle (1.5 per cent), and nine moth eggs (10 per cent) were found.

Porto Rican specimens now in my collection:
No. 139, female, Anegado Lagoon, March 29, 1924.
No. 254, male, Ensenada, Nov. 20, 1926.
No. 255, male, Ensenada, Nov. 20, 1926.

112. *VIREO OLIVACEUS OLIVACEUS* (Linné). Jamaican Vireo. Julián Chiví.

The Jamaican Vireo is a common summer resident in Porto Rico, usually arriving in February (sometimes late in January) and leaving in September. From the time of its arrival until August its characteristic song of *John-to-whit* is heard on every side. For the last few weeks of its stay with us the song is seldom heard. The species is found wherever there are trees.

Spring-arrival dates are February 12, 1922, February 14, 1924, January 27, 1927, February 18, 1928, February 18, 1929 and February 15, 1930, all at Mayagüez.

Late fall dates are September 8, 1924, September 10, 1927 and September 11, 1929, all at Mayagüez. I was attracted to the bird seen September 11, 1929 by hearing it sing its regular song, but much more softly and more slowly than during the breeding season. The bird was observed closely as it fed among the blossoms of a tree.

A stomach from Maricao contained 6 per cent of vegetable matter (four small seeds), and 94 per cent of animal matter (a Coreid bug, eight Lepidopterous larvae, two Lepidopterous pupae, and two fleabeetles, *Cryptocephalus krugi*).

Localities at which I have observed Jamaican Vireos are: Aguada, Moca, San Sebastián, Aguada, Rincón, Añasco, Mayagüez, Consomo,

Maricao, Las Marías, Hormigueros, Cabo Rojo, San Germán, Monte Grande, Sabana Grande, Faro de Cabo Rojo, Cartagena Lagoon, Parguera, Guayanilla, Jayuya, Orocovis, Ponce, Pastillo, Juana Díaz, Coamo Springs, Mameyes, El Yunque, Toa Alta, Vega Alta, Algarrobo, Manatí and Quebradillas.

Porto Rican specimens now in my collection:

No. 366, male, El Yunque (1,700 feet), Feb. 22, 1927.

No. 616, male, Mayagüez, April 20, 1928.

No. 726, female, Maricao, March 16, 1929.

113. *COEREBA PORTORICENSIS PORTORICENSIS* (Bryant). Porto Rican Honey Creeper. Reinita.

The Honey Creeper is the most abundant and generally distributed bird in Porto Rico. It is common everywhere and in every type of country from the highest mountain forests to the mangrove swamps of the coasts. It is less common than elsewhere in the brushy semiarid regions of the south coast.

Honey Creeper nests are familiar sights at all times of the year. Many dummy nests are built, and often torn down again as soon as finished to reuse the material in other nests, while others are used as sleeping quarters. The number of dummy nests found is greater than that of the nests used for breeding. Usually the nests are placed in trees at heights of from six to thirty-five feet from the ground. Ordinarily the nests are made of grasses and other plant fibers. Sometimes near where wild cotton is grown considerable quantities of the cotton is incorporated in the nests, and I have seen some nests which were made almost entirely of it.

Two extra low nests that I have found at Mayagüez were, one five feet in a coffee bush on February 13, 1928 containing five eggs, and another five feet in a spiny tree on May 2, 1928 containing three well fledged young which flew from the nest on my approach. It was only with difficulty that I captured one of them. A nest found at Boquerón on December 16, 1928 was placed even lower down, three and a half feet from the ground in a Lantana bush. It contained three newly hatched young.

The contents of three stomachs were examined. One contained a small weevil, another a beetle and a fly, and the third a small Lepidopterous larva and a beetle.

Honey Creepers are found at every locality on the island. I find them definitely recorded in my notes from the following: Point Borinquen, Aguadilla, San Sebastián, Aguada, Rincón, Añasco, Maya-

güez, Consomo, Las Marías, Maricao, Montoso Mountain, Hormigueros, Joyuda, Cabo Rojo, Puerto Real, Boquerón, Faro de Cabo Rojo (not common), San Germán, Monte Grande, Cartagena Lagoon (not common), Parguera, Lajas, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Guayanilla, Peñuelas, Tallaboa, Ponce, Adjuntas, Jayuya, Orocovis, Juana Díaz, Villalba, Coamo, Coamo Springs, Salinas, Guayama, Aibonito, Cayey, Caguas, Cidra, Aguas Buenas, Maunabo, Yabucoa, Humacao, Naguabo, Fajardo, Luquillo, Mameyes, El Yunque (common to the summit), Río Grande, Carolina, Trujillo Alto, Río Piedras, Martín Peña, Santurce, San Juan, Palo Seco, Bayamón, Vega Alta, Vega Baja, Algarrobo, Laguna Tortuguera, Manatí, Ciales, Naranjito, Corozal, Arecibo, Utuado, Camuy, Quebradillas and Isabela.

Porto Rican specimens now in my collection:

No. 142, male, Mayagüez, Dec. 21, 1923.
No. 143, female, Boquerón, Sept. 22, 1926.
No. 230, male, Mayagüez, Nov. 1, 1926.
No. 256, male, summit of Montoso Mountain, Nov. 24, 1926.
No. 611, male, imm. Mayagüez, April 15, 1928.
No. 612, male, imm. Mayagüez, April 15, 1928.

114. *MNIOTILTA VARIA* (Linné). **Black and White Warbler. Reinita.**

The Black and White Warbler is a fairly common and regular winter visitant, found mostly in wooded regions, but occasionally in brushy areas and mangrove swamps. It quite often sings soon after its arrival in the fall, and on one occasion (April 6, 1929 at Quebradillas) I observed one singing in the spring.

I once observed one of these warblers experiencing great difficulty in swallowing a lizard as long as itself. Two stomachs contained nothing but animal matter. Lepidopterous larvae formed 74 per cent, Fulgoridae 5 per cent, fleabeetles 6 per cent, a katydid nymph 5 per cent, a spider 3.5 per cent, and miscellaneous insects 6.5 per cent.

Early fall dates are October 12, 1924 (Mayagüez); October 6, 1926 (Monte Grande), October 29, 1927 (Mayagüez), and October 12, 1928 (Consomo).

Late spring dates are April 29, 1922 (Mayagüez); April 21, 1924 (Mayagüez); April 30, 1927 (Algarrobo); April 15, 1928 (Mayagüez); April 6, 1929 (Quebradillas), and April 24, 1930 (Algarrobo; Nina G. Spaulding).

Localities at which I have observed the species are: Añasco, Mayagüez, Las Marías, Maricao, Consomo, Montoso Mountain, Monte Grande, Cartagena Lagoon, Yauco, Coamo Springs, Mameyes, El Yunque, Santurce, Algarrobo, and Quebradillas.

Porto Rican specimens now in my collection:

No. 148, male, Mameyes, Oct. 12, 1926.

No. 238, male, Mayagüez–Maricao Road, Nov. 8, 1926.

No. 656, female, Las Marías, Oct. 12, 1928.

115. *COMPSOTHLYPIS AMERICANA PUSILLA* (Wilson). Northern Parula Warbler. Reinita.

The Parula Warbler is the most abundant of the migrant warblers that winter in Porto Rico. It is found in brushy as well as wooded regions.

Three stomachs contained nothing but insects, largely beetles and their larvae, among which *Cryptocephalus* sp. could be recognized. Lepidopterous larvae (Geometrid and others) also formed 32.3 per cent of the stomach contents.

For several weeks before these warblers start for the North in the spring they are in full song. First song dates are March 22, 1924, March 15, 1927, March 28, 1928, and March 16, 1929. In 1930 one was heard to sing on February 23, but no others were heard until March 16, after which they were heard frequently. In the fall I have heard them sing upon only a few occasions in October (October 16 and 23, 1926). This and the Black and White Warbler are the only two species of migratory warblers that I have heard sing at all during their winter stay with us.

Early fall dates are: September 29, 1924 (Mayagüez); October 16, 1926 (Mayagüez); November 8, 1928 (Mayagüez), and November 11, 1929 (Añasco).

Late spring dates are: April 15, 1922 (Mayagüez); May 2, 1924 (Cartagena Lagoon); April 25, 1927 (Consomo); May 3, 1928 (Mayagüez); April 29, 1929 (San Germán), and April 24, 1930 (Algarrobo, Nina G. Spaulding).

Localities at which I have observed Parula Warblers are: Aguada, San Sebastián, Añasco, Mayagüez, Consomo, Las Marías, Maricao, Montoso Mountain, Hormigueros, San Germán, Puerto Real, Boquerón, Cartagena Lagoon, Parguera, Anegado Lagoon, Ensenada, Yauco, Peñuelas, Ponce, Coamo Springs, Algarrobo, and Quebradillas.

Porto Rican specimens now in my collection:
No. 241, Mayagüez, Nov. 10, 1926.
No. 666, male, Montoso Mt., Nov. 17, 1928.
No. 670, female, San Sebastián, Nov. 24, 1928.
No. 718, male, Coamo Springs, Feb. 10, 1929.

116. *DENDROICA TIGRINA* (Gmelin). Cape May Warbler. Reinita.

The Cape May Warbler is a very rare winter visitant in Porto Rico. At Mayagüez I saw one on February 19, 1922, one on March 17, 1922, and an adult male on March 16, 1929. On Montoso Mountain on November 24, 1926 I shot two, but was unable to recover either. At Cartagena Lagoon I observed one on November 30, 1923. Miss Nina G. Spaulding reports seeing one at Santurce on February 19, 1930.

117. *DENDROICA PETECHIA CRUCIANA* Sundevall. Porto Rican Golden Warbler. Canario. Canario de Manglares.

The Golden Warbler is a common resident in Porto Rico. It is most abundant in the mangrove swamps. It is common at Cartagena Lagoon. In some places it is found in dry brushy regions, and in a few places in the coastal plain, as at Boquerón and Lajas, it is even found in the shade trees in the towns.

Stomachs contained nothing but insects.

I have observed Golden Warblers at Aguada, Añasco, Mayagüez (Caño Corazón, mouth of the Guanajibo River, and Correccional Point), Hormigueros, Joyuda, Puerto Real, Cabo Rojo, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Parguera, Cayo Enrique, Guánica Lagoon, Anegado Lagoon, Guayanilla, Tallaboa, Pastillo, Santa Isabel, Coamo Springs, Patillas, Fajardo, Río Blanco, San Juan, Laguna Tortuguera, Camuy, and Quebradillas.

Porto Rican specimens now in my collection:
No. 154, male, Cartagena Lagoon, March 17, 1924.
No. 233, male, Puerto Real, Nov. 3, 1926.
No. 609, male, Boquerón, April 16, 1928.
No. 633, male, Boquerón, Sept. 3, 1928.
No. 739, male, Cartagena Lagoon, March 9, 1929.

118. *DENDROICA MAGNOLIA* (Wilson). Magnolia Warbler. Reinita.

I have seen none since those recorded in my "Birds of the Cartagena Lagoon".

119. *DENDROICA CAERULESCENS CAERULESCENS* (Gmelin). **Black-throated Blue Warbler. Reinita.**

The Black-throated Blue Warbler is a common winter visitant in the wooded hills of Porto Rico, but it is rare near the coast. I have collected specimens at Añasco and on Montoso Mountain. A stomach contained nothing but insects, among which a fleabeetle (*Cryptocephalus* sp) was recognized.

Early fall dates are October 23, 1926 (Mayagüez–Maricao Road), and October 12, 1928 (Consomo). My latest spring date is April 15, 1922 (Maricao).

Localities at which I have observed the species are: Aguada, Añasco, Mayagüez, Consomo, Maricao, Montoso Mountain, Monte Grande, Aibonito and El Yunque.

Porto Rican specimen now in my collection:
No. 668, male, Montoso Mt., Nov. 17, 1928.

120. *DENDROICA CORONATA* (Linné). Myrtle Warbler. Reinita.

The Myrtle Warbler is a rather irregularly and locally common winter visitant in Porto Rico. It occurs most commonly in rather dry brushy regions. It does not arrive until well along in the winter, and is the first of the North American migrants to leave in the spring. It is more abundant during the latter part of its stay.

The food in two stomachs consisted entirely of animal matter, of which spiders formed 7.5 per cent, moths 10 per cent, weevils 7.5 per cent, and Lepidopterous larvae 5 per cent. A little sand, forming 4 per cent of the total contents, was also found.

Early arrival dates are December 14, 1923 (Cartagena Lagoon); November 20, 1926 (hills south of Anegado Lagoon); December 10, 1927 (Cartagena Lagoon), and December 16, 1928 (Cartagena Lagoon).

Late spring dates are: April 8, 1922 (Cartagena Lagoon); April 1, 1924 (Cartagena Lagoon); March 28, 1927 (Cartagena Lagoon); April 7, 1928 (Cartagena Lagoon), and March 24, 1929 (Coamo Springs).

Localities at which I have observed this warbler are: Mayagüez (rare); Boquerón, Faro de Cabo Rojo, Cartagena Lagoon (irregularly common), Anegado Lagoon, Coamo Springs, and Algarrobo.

Porto Rican specimens now in my collection:
No. 252, male, imm., hills south of Anegado Lagoon, Nov. 20, 1926.
No. 375, female, Cartagena Lagoon, March 7, 1927.

121. *DENDROICA DOMINICA DOMINICA* (Linné). Yellow-throated Warbler. Reinita.

The Yellow-throated Warbler is a rare winter visitant to Porto Rico. At Mayagüez I have recorded single birds on five occasions (November 11, 1921; December 31, 1921; December 19, 1923; December 27, 1923, and January 23, 1924). On December 18, 1926 I collected a male in a cocoanut grove at Boquerón. Its stomach contained insects, mainly Coleoptera, but also including one Lepidopterous larva.

Porto Rican specimen now in my collection:
No. 275, male, Boquerón, Dec. 18, 1926.

122. *DENDROICA ADELAIDAE* Baird. Adelaide's Warbler. Reinita.

Adelaide's Warbler is a common but locally distributed bird in Porto Rico. It is preeminently a bird of dry brushy regions, and of the tangled brushy vegetation found on limestone hills. It is very active, and feeds where the vegetation is dense; for that reason it is rather hard to observe, even where its persistent song is heard on every side. The song is a loud trill.

A stomach from near Mayagüez was filled with insects and their eggs. An aphid, beetles (including a small Coccinellid), Diptera, and two kinds of insect eggs were noted.

Localities at which I have observed Adelaide's Warblers are: Point Borinquen, Aguadilla, Aguada, Mayagüez (Correccional Point), Puerto Real, Monte Grande, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Guayanilla, Tallaboa, Coamo Springs, Mameyes, Vega Alta, Algarrobo and Quebradillas.

Porto Rican specimens now in my collection:
No. 150, male, Cartagena Lagoon, Sept. 23, 1924.
No. 151, female, Guánica Lagoon, Oct. 3, 1924.
No. 242, Imm., Mayagüez (Correccional Point), Nov. 10, 1926.
No. 734, male, Cartagena Lagoon, Feb. 14, 1929.

123. *DENDROICA STRIATA* (J. R. Forster). Blackpoll Warbler. Reinita.

On only one occasion have I observed the Blackpoll Warbler in Porto Rico. That was on October 13, 1928, when the trees and shrubs south of Cartagena Lagoon fairly swarmed with them. I counted up to 150 of them, and am sure there were many more. Two were collected. Their stomachs contained comminuted insects,

largely small Homoptera. A small Lepidopterous larva and a few Coleopterous fragments were also recognized.

Porto Rican specimens now in my collection:
No. 657, female, Cartagena Lagoon, Oct. 13, 1928.
No. 658, male, Cartagena Lagoon, Oct. 13, 1928.

124. *DENDROICA DISCOLOR* (Vieillot). **Prairie Warbler. Reinita.**

The Prairie Warbler is a winter visitant in Porto Rico. Most years it is quite common, but some years it is very rare. In the winter of 1928–29 it was extremely scarce. While here it frequents for the most part brushy regions, and is particularly common in the bushes growing back of beaches. On a number of occasions I have observed it in coffee woods.

Two stomachs were filled with insects, almost exclusively Coleoptera. Small fleabeetles and small Elateridae figured largely.

Early fall dates are September 20, 1924 (Cartagena Lagoon); October 2, 1926 (Guánica Lagoon), and October 29, 1927 (Mayagüez).

Late spring dates are April 22, 1922, April 4, 1924, April 23, 1927, and April 7, 1928 at Cartagena Lagoon, and April 3, 1930 at Mayagüez.

Localities at which I have observed Prairie Warblers are: Aguada, Mayagüez, Puerto Real, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Anegado Lagoon, Guánica Lagoon, Ensenada, Coamo Springs, Mameyes, Algarrobo, and along the Arecibo–Utuado Road.

Porto Rican specimens now in my collection:
No. 360, female, Boquerón, Feb. 14, 1927.
No. 661, male, Puerto Real, Nov. 6, 1928.

125. *DENDROICA PALMARUM PALMARUM* (Gmelin). **Palm Warbler. Reinita.**

The Palm Warbler is a rare winter visitant to Porto Rico. On three occasions (December 18, 1926, February 14, 1927 and December 16, 1928) I have observed single individuals at the same spot back of the beach at Boquerón.

Porto Rican specimen now in my collection:
No. 708, female, Boquerón, Dec. 16, 1928.

126. *SEIURUS NOVEBORACENSIS NOVEBORACENSIS* (Gmelin).) **Water-thrush. Pizpita. Pizpita de manglares.**

The Water-thrush is an abundant winter visitant in Porto Rico. It is found most abundantly in the mangroves, but is common at

fresh water lagoons and along streams. Next to the Parula Warbler I believe this to be the most abundant wintering warbler in Porto Rico. Stomachs contained comminuted insects, largely Coleoptera.

Early fall dates are: September 3, 1924 (Cartagena Lagoon); September 22, 1926 (Boquerón); September 16, 1927 (Mayagüez); September 21, 1928 (Mayagüez); September 29, 1929 (Coamo Springs).

Late spring dates are: April 22, 1922 (Cartagena Lagoon); April 30, 1924 (Cartagena Lagoon); April 23, 1927 (Cartagena Lagoon); April 30, 1928 (Joyuda); April 18, 1929 (Boquerón), and April 17, 1930 (Aguada).

Localities at which I have observed Water-thrushes are: Aguada, Añasco, Mayagüez, Las Marías, Consomo, Maricao, Hormigueros, San Germán, Joyuda, Puerto Real, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Anegado Lagoon, Guánica Lagoon, Peñuelas, Lares–Yauco Road, Ponce, Santa Isabel, Coamo Springs, Fajardo, Mameyes, Cidra, and Quebradillas.

Porto Rican specimens now in my collection:
No. 161, male, Cartagena Lagoon, April 8, 1924.
No. 163, male, San Germán, Oct. 9, 1926.
No. 232, female, Puerto Real, Nov. 3, 1926.
No. 603, male, Consomo, April 6, 1928.
No. 604, male, Consomo, April 6, 1928.

127. *SEIURUS NOVEBORACENSIS NOTABILIS* Ridgway. Grinnell's Water-thrush. Pizpita. Pizpita de Manglares.

This is probably a rare winter visitant in Porto Rico. The only positive record I have is a male which I shot at Mayagüez on November 29, 1926. Its stomach was empty.

Porto Rican specimen now in my collection:
No. 261, male, Mayagüez, Nov. 29, 1926.

128. *SEIURUS MOTACILLA* (Vieillot). Louisiana Water-thrush. Pizpita.

The Louisiana Water-thrush is a fairly common winter visitant in Porto Rico. It frequents mostly swiftly running streams in the interior hills, but is found to some extent along streams in the coastal plain, at fresh water lagoons, and even in the mangrove swamps. Two stomachs contained nothing but comminuted insects, among which a small Carabid beetle and a small wingless cockroach were recognized.

Early fall dates are: September 6, 1924 (Mayagüez); October 29, 1927 (Mayagüez), and October 12, 1928 (Consomo).

Late spring dates are: April 10, 1924 (Mayagüez); April 21, 1927 (Mayagüez), and April 14, 1928 (Mayagüez).

Localities at which I have observed this species are: Añasco, Mayagüez, Consomo, Las Marías, Maricao, Cartagena Lagoon, and Coamo Springs.

Porto Rican specimen now in my collection:
No. 270, male, Las Marías, Dec. 4, 1926.

129. *SEIURUS AUROCAPILLUS AUROCAPILLUS* (Linné). Ovenbird. Pizpita. Pizpita Dorada.

The Ovenbird is a common winter visitant in Porto Rico. It is found most frequently in the coffee woods, but it is not unusual to find it in brushy regions. It never sings while with us, but its vigorous scold note can often be heard protesting against some passing mongoose or other would-be enemy.

Two stomachs contained 89 per cent vegetable matter and 11 per cent animal matter. The latter consisted of beetles and a smooth white caterpillar. The vegetable matter was formed of seeds and small fruits. Considerable sand was also found in one of the stomachs.

Early fall dates are: September 24, 1924 (Mayagüez); September 18, 1927 (Mayagüez); and October 12, 1928 (Mayagüez–Maricao Road).

Late spring dates are: April 20, 1922, April 10, 1924, April 22, 1928, and April 25, 1929 at Mayagüez, and April 16, 1930 at Consomo.

Localities at which I have observed Ovenbirds are: Añasco, Mayagüez, Maricao, Consomo, Las Marías, Puerto Real, Monte Grande, Cartagena Lagoon, Yauco, and Coamo Springs.

Porto Rican specimens now in my collection:
No. 165, male, Mayagüez–Maricao Road, Oct. 23, 1926.
No. 247, female, Añasco, Nov. 17, 1926.

130. *GEOTHLYPIS TRICHAS BRACHIDACTYLA* (Swainson). Northern Yellowthroat. Reinita.

The Yellowthroat is a very rare winter visitant in Porto Rico. On April 18, 1924 I observed a male at Cartagena Lagoon, and on December 10, 1927 a pair in a flooded weed-grown canefield at the

edge of Cartagena Lagoon. On January 5, 1930 I heard the characteristic scold notes of this species in thick undergrowth near a stream at Hormigueros.

131. *SETOPHAGA RUTICILLA* (Linné). Redstart. Reinita. Candelita.

The Redstart is a common winter visitant in Porto Rico. It is most abundant in wooded regions, but is also found not uncommonly in shade trees, mangrove swamps, and brushy regions. Birds in the female and immature male plumages are more frequently seen than brilliantly plumaged males.

Early fall dates are: October 7, 1924 (Carfagena Lagoon); September 22, 1926 (Boquerón), and October 6, 1928 (Guayama).

Late-spring dates are: April 26, 1924 (Faro de Cabo Rojo); May 3, 1928 (Mayagüez); April 27, 1929 (Hormigueros), and April 27, 1930 (Mayagüez). On May 3, 1928 five in female plumage were noted in a single tree at Mayagüez.

Localities at which I have observed Redstarts are: San Sebastián, Añasco, Mayagüez, Maricao, Las Marías, Consomo, Montoso Mountain, Hormigueros, San Germán, Monte Grande, Joyuda, Puerto Real, Boquerón, Cartagena Lagoon, Ensenada, Coamo Springs, Guayama, Río Piedras and Algarrobo.

Porto Rican specimen now in my collection:
No. 237, male, Mayagüez–Maricao Road, Nov. 8, 1926.

132. *SPERMESTES CUCULLATUS CUCULLATUS* Swainson. Hooded Weaver Finch. Diablito. Gorrión.

The Hooded Weaver Finch is a species introduced from West Africa. It is a locally common species on the coastal plain of Porto Rico. It is rare in the hills, and is less common on the dry south coast than in other parts of the coastal plain. Occasionally this species is found in mixed flocks with the Scarlet-cheeked species. Its principal food is the seeds of the guinea grass.

Localities at which I have observed the species are: San Sebastián, Añasco, Mayagüez, San Germán, Monte Grande, Cabo Rojo, Boquerón, Cartagena Lagoon, Lajas, Yauco–Lares Road, Ciales, Villalba–Ciales Road, Mameyes and Río Piedras.

Porto Rican specimens now in my collection:
No. 262, male, Mayagüez, Nov. 29, 1926.
No. 545, male, Boquerón, Sept. 10, 1927.

133. *ESTRILDA MELPODA MELPODA* (Vieillot). **Scarlet-cheeked Weaver Finch. Chamorro. Gorrión.**

The Scarlet-cheeked Weaver Finch is another species introduced from West Africa, but in Porto Rico it is confined to the southwest corner of the island. It has been recorded from Añasco to Santa Isabel, but is common only from Mayagüez to Anegado Lagoon. Its center of abundance is in the region from Boquerón to Cartagena Lagoon. I have personally encountered the species only at the following localities: Añasco, Mayagüez, Monte Grande, Boquerón, Cartagena Lagoon, Anegado Lagoon, Guánica Lagoon, and Peñuelas.

Porto Rican specimens now in my collection:
No. 181, male, Cartagena Lagoon, March 21, 1926.
No. 239, male, Mayagüez, Nov. 10, 1926.
No. 659, female, Boquerón, Oct. 27, 1928.

134. *AGELAIUS XANTHOMUS* (Sclater). Yellow-shouldered Blackbird. Mariquita.

The Yellow-shouldered Blackbird is a common resident in Porto Rico. It is essentially a bird of the lowlands, but is by no means confined to the swamps. It usually nests in small colonies in palms or other tall trees. The birds are gregarious, and occur in small flocks at all times. When it is not the breeding season as many as fifty birds may occur in a flock. At that time mixed flocks of this species and *Holoquiscalus* are also frequently encountered. During the winter a large flock of Yellow-shouldered Blackbirds congregates near the poultry yards of the College of Agriculture at Mayagüez to pick up what grain they can steal. But on the whole the species is beneficial and it subsists largely on insects. I found Lepidopterous larvae and pupae forming nearly three-quarters of the food in the stomachs that I examined.

Localities at which I have observed the species are: Aguada, Rincón, Añasco, Mayagüez, Joyuda, Hormigueros, Filial Amor, Cabo Rojo, San Germán, Sabana Grande, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Anegado Lagoon, Ensenada, Tallaboa, Peñuelas, Juana Díaz, Coamo Springs, Central Aguirre, Río Piedras, Toa Baja, Comerío, hills above Ciales, Manatí, Arecibo, and Isabela.

Porto Rican specimens now in my collection:
No. 167, male, Cartagena Lagoon, April 1, 1924.
No. 228, female, Cartagena Lagoon, Oct. 30, 1926.
No. 229, female, Cartagena Lagoon, Oct. 30, 1926.
No. 547, female, Cartagena Lagoon, Sept. 17, 1927.

No. 596, male, Mayagüez, March 14, 1928.
No. 598, male, Mayagüez, March 14, 1928.
No. 599, male, Mayagüez, March 14, 1928.
No. 600, male, Mayagüez, March 14, 1928.
No. 601, female, Mayagüez, March 14, 1928.
No. 602, female, Mayagüez, March 14, 1928.

135. *ICTERUS PORTORICENSIS* Bryant. **Porto Rican Oriole. Calandria.**

The Oriole is a common resident, universally distributed wherever there are trees. However, I did not find it above an altitude of 1,700 feet on El Yunque. Usually this species occurs singly, or in pairs or small family groups. On one occasion (February 26, 1929 at Mayagüez) I observed the very unusual sight of a flock of thirteen adults and one bird in immature plumage. They flew overhead making a noisy chorus of call notes.

Four stomachs contained 60.5 per cent of animal matter and 29.5 per cent of vegetable material. The latter consisted of small greenish seeds and red-seeded berries. Coleoptera formed 26 per cent of the contents, a centipede 21.2 per cent, and Lepidopterous larvae 10.5 per cent.

The Oriole is perhaps the finest songster in Porto Rico, but it does not sing very freely, although the song is heard occasionally at all times of the year.

I have observed Orioles at: San Sebastián, Aguada, Rincón, Añasco, Mayagüez, Maricao, Consomo, Las Marías, Montoso Mountain, Hormigueros, Cabo Rojo, Monte Grande, Sabana Grande, Joyuda, Puerto Real, Boquerón, Faro de Cabo Rojo, Cartagena, Lagoon, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Tallaboa, Peñuelas, Jayuya, Villalba, Coamo Springs, Maunabo, Yabucoa, Mameyes, El Yunque, Aguas Buenas, Juncos, Santurce, Vega Alta, Algarrobo, Arecibo–Utuado Road, Morovis, and Quebradillas.

Porto Rican specimens now in my collection:
No. 170, male, imm., Mayagüez, Dec. 25, 1923.
No. 171, male, ad., Guánica Lagoon, Oct. 3, 1924.
No. 172, male, ad., Boquerón, Sept. 22, 1926.
No. 173, male, imm., Mameyes, Oct. 12, 1926.
No. 717, female, imm., Monte Grande, Feb. 7, 1929.
No. 740, male, ad., Maricao, March 16, 1929.

136. ***HOLOQUISCALUS NIGER BRACHYPTERUS*** **(Cassin). Porto Rican Grackle. Mozambique. Chango. Pichón Prieto.**

The Grackle is the most abundant bird in the coastal plain of Porto Rico, though it is somewhat rare in the dry sagebrush regions. It is also found in the foothills, but not in the high mountains.

The Grackle nests from March to August, usually in palm trees, but often in other trees, or even in the cattails. On August 13, 1927 near Cartagena Lagoon I found a colony of nests in a Guazama tree containing new hatched young. On March 19, 1927, near Mr. Burlingame's house at Algarrobo I observed a colony of ten nests in a Ceiba tree. Mr. Burlingame told me that they had been nesting for about two weeks. On April 27, 1928 I observed a pair nest building in a cocoanut palm at Hormigueros. On March 22, 1930 I made observation of a pair which had a nest of coarse grass built on the girders of a large iron bridge over a river near Toa Alta.

On one occasion I watched a Grackle clinging upside down on the udder of a cow, picking off something. The cow seemed to enjoy the process and stayed perfectly still.

I have observed Grackles at: Aguadilla, San Sebastián, Coloso, Aguada, Rincón, Mayagüez, Joyuda (rare), Puerto Real, Hormigueros, Cabo Rojo, Filial Amor, Monte Grande, San Germán, Sabana Grande, Guanaquilla, Boquerón, Faro de Cabo Rojo (rare), Cartagena Lagoon, Lajas, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Guayanilla, Peñuelas, Jayuya, Orocovis, Ponce, Santa Isabel, Coamo Springs, Salinas, Central Aguirre, Guayama, Maunabo, Yabucoa, Humacao, Fajardo, Luquillo, Loíza, Mameyes, El Yunque (at low elevations), Río Grande, Trujillo Alto, Río Piedras, Martin Peña, San Juan, Caguas, San Lorenzo, Aguas Buenas, Juncos, Pueblo del Río, Bayamón, Vega Alta, Toa Baja, Toa Alta, San Vicente, Vega Baja, Algarrobo, Manatí, Ciales, Barceloneta, Bajadero, Florida, Cidra, Comerío, Naranjito, Arecibo, Hatillo, Camúy, Quebradillas and Isabela.

Porto Rican specimens now in my collection:

No. 178, female, Cartagena Lagoon, March 21, 1924.
No. 179. female, Cabo Rojo, Oct. 6, 1926.
No. 180, male, Cabo Rojo, Oct. 6, 1926.
No. 266, female, Aguada, Dec. 1, 1926.
No. 709, female, Cartagena Lagoon, Jan. 12, 1929.
No. 710, male, Cartagena Lagoon, Nov. 10, 1928.

137. *NESOSPINGUS SPECULIFERUS* (Lawrence). Porto Rican Tanager. Llorón.

I have found Nesospingus only on the forested slopes of El Yunque above 1,700 feet elevation, and in the hills in the vicinity of Maricao. In both these regions is it a common bird. In the second growth woods in the National Forest near Maricao this is the commonest bird, even exceeding the Money Creeper in abundance. Birds collected in February were apparently nearly ready to breed.

The iris of these birds is brown, of about the same shade as the wing. The upper mandible is dusky brown, and the lower is horn color. The legs and feet are bluish gray. The soles are yellow, and the claws grayish brown.

Three stomachs contained 93.3 per cent of vegetable matter and 6.7 per cent of animal matter. The latter consisted of a large Lepidopterous larva in one stomach. The vegetable matter was formed of seeds and small fruits.

Porto Rican specimens now in my collection:
No. 362, male, El Yunque, Feb. 20, 1927.
No. 363, male, El Yunque, Feb. 20, 1927.
No. 364, female, El Yunque, Feb. 21, 1927.
No. 365, male, El Yunque, Feb. 22, 1927.
No. 593, female, East of Maricao, Feb. 4, 1928.
No. 712, female, Maricao, Jan. 26, 1929.
No. 736, male, Maricao, March 16, 1929.

138. *SPINDALIS PORTORICENSIS* (Bryant). Porto Rican Spindalis. Reina Mora. Come Ñame.

The Spindalis is a very common bird in the wooded regions of Porto Rico, in the lowlands and hilly country alike. It is sometimes found even in the mangrove swamps. When food is abundant it is often found in loose flocks, sometimes containing as many as twenty individuals. The food, as determined by field observations and by the examination of stomach contents, consists entirely of fruits.

The song of the Spindalis is inconspicuous and easily overlooked unless one is familiar with it, but once learned it is a song that one will hear frequently in many regions. The notes have much the same quality as those of the Honey Creeper, but they are slightly higher pitched, and are repeated in regular cadence, often for a considerable length of time. It might be described as a rather fine, squeaky, unmusical, wiry *tswee, tswee, tsweey,* continued more or

less indefinitely, with a certain amount of rhythm. This song is frequently heard throughout the year, except during a short period from the middle of November until nearly the middle of January, when it is seldom heard. The Spindalis also has a faint, lisping *tsweep* call note, and I have heard fighting males make some harsh scolding notes which might be rendered as *krukky-krurr-r-r-r*.

On March 22, 1927 at Algarrobo I found a nest placed five and a half feet above the ground in a "cocorón" tree. The nest was a shallow cup-shaped affair, made of coarse plant stems, and lined with finer ones. It contained three young with their eyes not yet open. The brooding bird, which was in typical female plumage, but with a large, orange spot on its breast, was not at all shy, and came to feed and brood the young while I was watching from within a few feet. The young were deep reddish orange, sparsely covered with gray fuzzy down.

Localities at which I have observed the Spindalis are: San Sebastián (common); Añasco (common); Rincón (rare); Mayagüez (common); Las Marías (common); Consomo (common); Maricao (common); Montoso Mountain (common); Joyuda and Puerto Real (in mangrove swamps); Monte Grande (common); San Germán; Boquerón (rare in mangrove swamps); Cartagena Lagoon (rare); Yauco; Peñuelas; Coamo Springs (common); Guayama; Aguas Buenas; Cidra; El Yunque (common); Algarrobo (common).

Porto Rican specimens now in my collection:

No. 184, male, Mayagüez, Oct. 16, 1926.
No. 185, male, Mayagüez–Maricao Road, Oct. 23, 1926.
No. 234, male, Puerto Real, Nov. 3, 1926.
No. 250, female, Mayagüez, Nov. 17, 1926.
No. 263, male, Mayagüez,, Nov. 29, 1926.
No. 355, male, Añasco, Jan. 24, 1927.
No. 614, male, imm., Mayagüez, April 17, 1928.
No. 733, female, Mayagüez, March 14, 1929.

139. *TANAGRA SCLATERI* (Sundevall). Porto Rican Euphonia. Canario del País. Jilguero.

The Euphonia is a bird that is somewhat locally distributed in Porto Rico, being found principally in the hills, and where mistletoe is abundant, though I have observed the species practically at sea level near Mayagüez.

I have observed this species only at Añasco, Mayagüez, Montoso Mountain, Consomo, and on El Yunque (at 1,500 feet).

Porto Rican specimens now in my collection:
No. 244, male, Añasco, Nov. 13, 1926.
No. 271, male, Consomo, Dec. 4, 1926.
No. 272, female, Consomo, Dec. 4, 1926.
No. 367, female, El Yunque (1,500 feet), Feb. 22, 1927.

140. *MELOSPIZA LINCOLNII* (Audubon). Lincoln's Sparrow.

On December 14, 1923 I saw one in a brush pile near La Plata, but as the record is so unusual, and the specimen was not collected, the species can be listed only hypothetically for Porto Rico.

141. *TIARIS BICOLOR OMISSA* Jardine. Carib Grassquit. Gorrión.

The Carib Grassquit is an abundant resident in Porto Rico. It far exceeds the Bryant's Grassquit in abundance except at the extreme east end of the island, and in a few other limited localities. It is primarily a bird of the open country at lower levels, but at times occurs well up into the mountains and even in the coffee woods; indeed I have even found their nests in the coffee woods. On one occasion (September 22, 1926) I found a nest with two eggs in a mangrove swamp at Boquerón. It was placed four and a half feet above the water in a small mangrove.

Several stomachs contained nothing but seeds and small berries; also a little sand for grinding the seeds.

Localities at which I have observed Carib Grassquits are: Point Borinquen, Aguadilla, San Sebastián, Aguada, Rincón, Añasco, Mayagüez, Maricao, Consomo, Las Marías, Montoso Mountain, Joyuda, Puerto Real, Hormigueros, Cabo Rojo, Monte Grande, San Germán, Sabana Grande, Guanaquilla, Boquerón, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Parguera, Anegado Lagoon, Guánica Lagoon, Ensenada, Yauco, Lares–Yauco Road, Guayanilla, Tallaboa, Ponce, Juana Díaz, Guayabal Reservoir, Villalba, Coamo Springs, Salinas, Guayama, Patillas, Maunabo, Humacao, Naguabo, Mameyes, Río Piedras, Santurce, San Juan, San Lorenzo, Juncos, Pueblo del Río, Bayamón, Vega Alta, Laguna Tortuguera, Algarrobo, Manatí, Ciales, Utuado, Camuy and Quebradillas.

Porto Rican specimens now in my collection:
No. 217, male, Yauco–Lares Road, Oct. 9, 1926.
No. 246, female, Añasco, Nov. 7, 1926.
No. 274, female, Anegado Lagoon, Dec. 18, 1926.

142. *TIARIS OLIVACEA BRYANTI* (Ridgway). **Bryant's Grassquit. Gorrión.**

Bryant's Grassquit is a common resident in Porto Rco, but it is less common than the preceding species except in a few localities, such as the semi-barren low-lying hills at the east end of the island, and certain unwooded hills in the interior of the island. It is preeminently a bird of open and grassy country, and frequents thickets much less freely than its relative.

I have recorded the species at San Sebastián, Aguada, Rincón, Añasco, Mayagüez, Mayagüez–Maricao Road, Las Marías, Consomo, Montoso Mountain, Filial Amor, San Germán, Puerto Real, Faro de Cabo Rojo, Cartagena Lagoon, Lajas, Anegado Lagoon, Guánica Lagoon, Ensenada, Guayanilla, Peñuelas, Tallaboa, Ponce, Pastillo, Santa Isabel, Villalba, Coamo Springs, Guayama, Yabucoa, Humacao, Ceiba, Fajardo, Mameyes, El Yunque (at lower elevations), Trujillo Alto, Río Piedras, Bayamón, Juncos, Pueblo del Río, San Lorenzo, Las Piedras, Caguas, Naranjito, Vega Alta, Algarrobo, Manatí, Arecibo, Arecibo–Utuado Road, Utuado, Adjuntas, Utuado–Ponce Road, and Quebradillas.

Porto Rican specimens now in my collection:
No. 259, male, Mayagüez, Nov. 25, 1926.
No. 606, female, San Sebastián, April 14, 1928.
No. 667, male, Montoso Mountain, Nov. 17, 1928.

143. *LOXIGILLA PORTORICENSIS* (Daudin). **Porto Rican Grosbeak. Capitán. Come Gandul. Capacho.**

The Grosbeak is a common resident in Porto Rico wherever there is sufficient cover. It is an inhabitant of well wooded regions and dense thickets. Occasionally it is found in some of the more dense growths of acacia scrub in the drier parts of the island. It is not unusual to find it in mangrove swamps. It is very rare in the eastern part of the island. With the exception of a few birds noted on El Yunque I have never observed the species east of Vega Alta and Coamo Springs.

I have observed two occupied nests of this species. On March 22, 1927 at Algarrobo I discovered a nest seven feet from the ground in a *mameyuelo* tree. The nest was rather bulky, like a basket tipped partly on its side so that it was partly covered above. It was loosely constructed of plant stems and skeletonized leaves. In fact it appeared so sloppy that I would easily have overlooked it believing it to

be an abandoned nest if I had not seen the incubating bird fly away. The nest contained three eggs, which were very light bluish green, spotted everywhere with reddish brown, the spots coalescing to some extent at the larger end.

The second nest was found on April 29, 1929 in some coffee woods near Mayagüez. It was made of coarse grasses, stems of plants bearing small fruits, and a little vegetable wool on the outside. The material used for the inside construction was coarser than that used outside; nevertheless the outside presented a very rough appearance, with fine stems projecting in every direction. The nest formed a very deep cup. It contained three very slightly incubated eggs. They were of the same color as those found in the first nest. Unfortunately two of them were accidentally broken before they could be measured, but the third measured 18 $\times$ 12.5 millimeters.

The loud characteristic song of the Grosbeak is heard to some extent at all times of the year, but far more frequently from February to June.

Of three stomachs, one contained solaneceous berries, another other berries, and the third finely ground seeds. Sand in two stomachs formed 20 per cent of the total contents.

Localities at which I have observed Porto Rican Grosbeaks are: San Sebastián, Añasco, Mayagüez, Maricao, Consomo, Montoso Mountain, Las Marías, Joyuda (rare), Monte Grande, Boquerón, Faro de Cabo Rojo (a few in brushy beach vegetation), Mariquita Hill (near Cartagena Lagoon), Parguera, hills south of Anegado Lagoon, Ensenada, Yauco, Tallaboa (in the dry acacia scrub), Ponce, Coamo Springs (not common), El Yunque, Vega Alta (common), Ciales, Utuado, Utuado–Adjuntas Road, and Quebradillas.

Porto Rican specimens now in my collection:

No. 240, male, Mayagüez, Nov. 10, 1926.
No. 245, male, Añasco, Nov. 17, 1926.
No. 249, male, Añasco, Nov. 17, 1926.
No. 552, female, Mayagüez, Dec. 13, 1927.

144. *AMMODRAMUS SAVANNARUM BORINQUENSIS* Peters.
Porto Rican Grasshopper Sparrow. Gorrión.

The Grasshopper Sparrow is a resident of dry grassy fields where the vegetation is not too high. In habits it is similar to its North American relative. The only nest I have ever found has been previously recorded in my "Birds of the Cartagena Lagoon".

The only localities at which I have observed the species are Cartagena Lagoon, Anegado Lagoon, Guánica Lagoon and Arecibo.

Porto Rican specimens now in my collection:

No. 198, male, Cartagena Lagoon, Oct. 3, 1924.

No. 199, male, Cartagena Lagoon, Sept. 25, 1926.

Explanation of Plates

Fig. 1. Map showing places visited for study.

Fig. 2. Brown Pelican in flight.
Cayo Enrique, August 15, 1927.
Photo by J. T. Emlen, Jr.

Fig. 3. Young Brown Pelicans in the nest.
Cayo Enrique, August 15, 1927.
Photo by J. T. Emlen, Jr.

Fig. 4. Common Booby on the nest.
Desecheo Island, May 8, 1927.
Photo by the author.

Fig. 5. Captive young Red-footed Booby from Desecheo Island.
May, 1927.
Photo by the author.

Fig. 6. Man-o-war Birds near their nests.
Cayo Enrique, August 15, 1927.
Photo by J. T. Emlen, Jr.

Fig. 7. Nest of Snowy Egret, with egg and newly hatched young.
Cayo Enrique, August 15, 1927.
Photo by J. T. Emlen, Jr.

Fig. 8. Egg of Least Tern.
Faro de Cabo Rojo, May 15, 1927.
Photo by the author.

Fig. 9. Nest and eggs of Least Tern.
Faro de Cabo Rojo, May 15, 1927.
Photo by the author.

Fig. 10. Porto Rican Short-eared Owl.
Anegado Lagoon, September 29, 1926.
Photo by the author.

Fig. 11. Porto Rican Short-eared Owl.
Anegado Lagoon, September 29, 1926.
Photo by the author.

Fig. 12. Nest of Fork-tailed Hummingbird.
Maricao, November 8, 1926.
Photo by the author.

Fig. 13. Closer view of nest of Fork-tailed Hummingbird.
Maricao, November 8, 1926.
Photo by the author.

Fig. 14. Porto Rican Spindalis feeding young.
Algarrobo, March 22, 1927.
Photo by the author.

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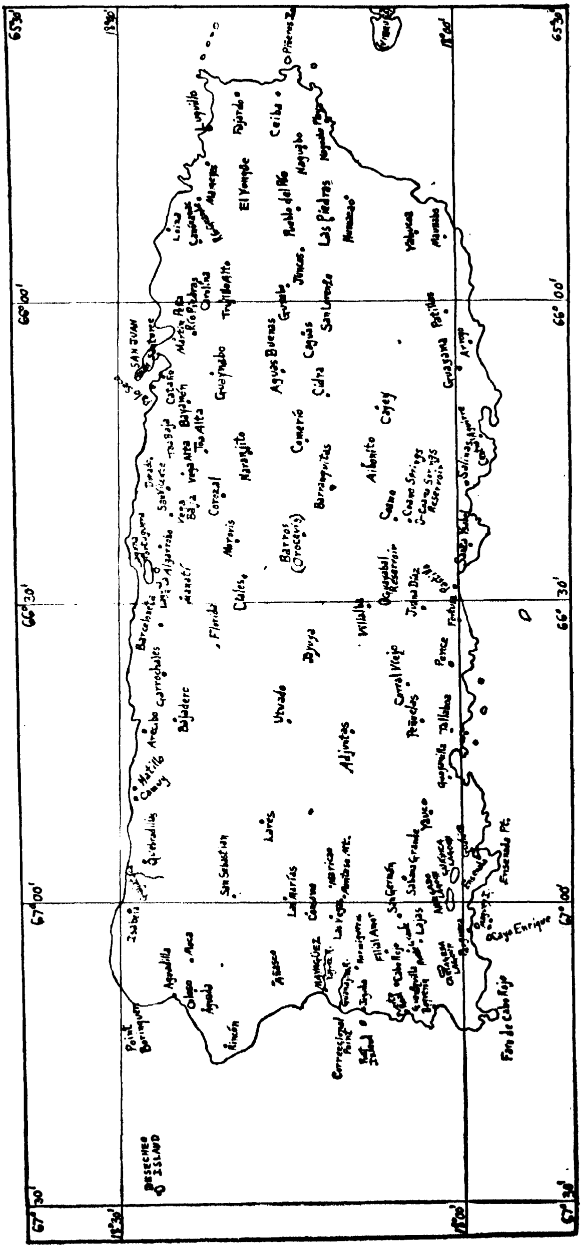
PLATE I.



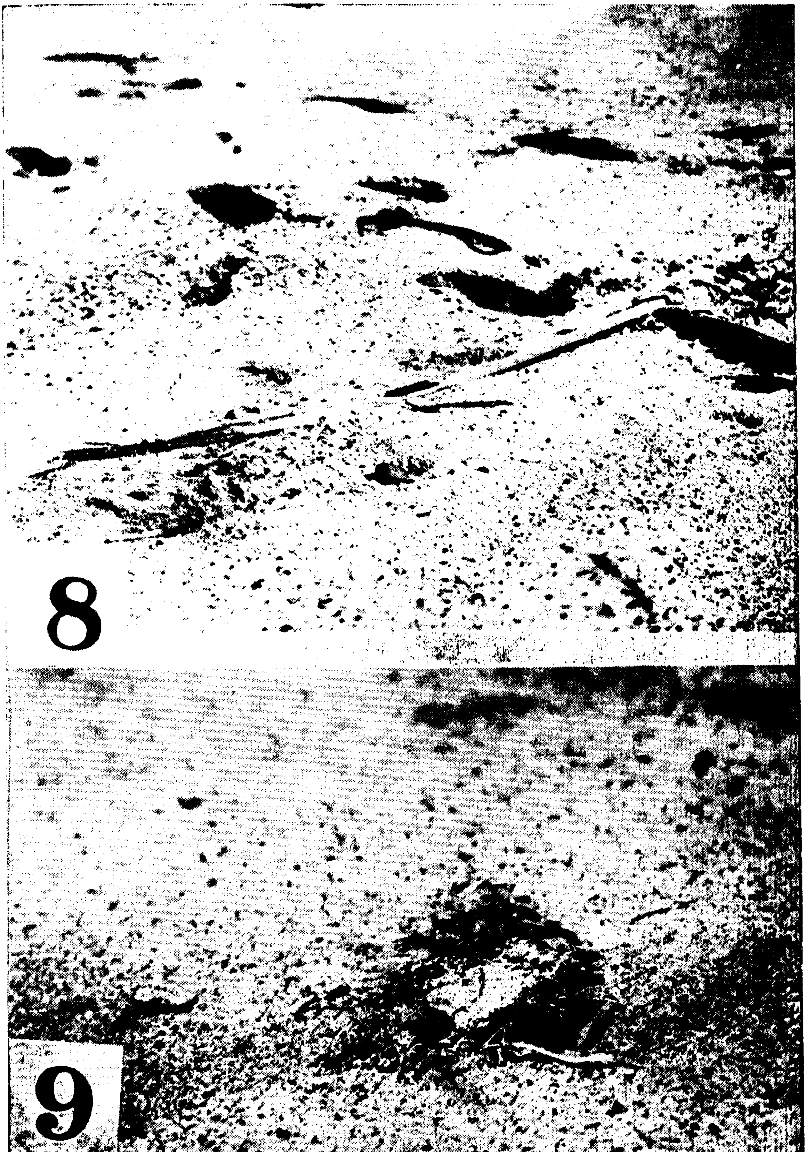
65° 30'
66° 00'
66° 30'
67° 00'
67° 30'
18° 30'
18° 00'
SAN JUAN
DESECHEO ISLAND
Point Borinquen
Aguadilla
Isabela
Rincón
Lares
Utuado
Adjuntas
Arecibo
Barceloneta
Ponce
Coamo
Aibonito
Cayey
Cidra
Caguas
Comerío
Guaynabo
Aguas Buenas
Fajardo
Ceiba
El Yunque
Las Piedras
Yabucoa
Guayama
Cabo Rojo

PLATE II.

2

3

PLATE IV.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10


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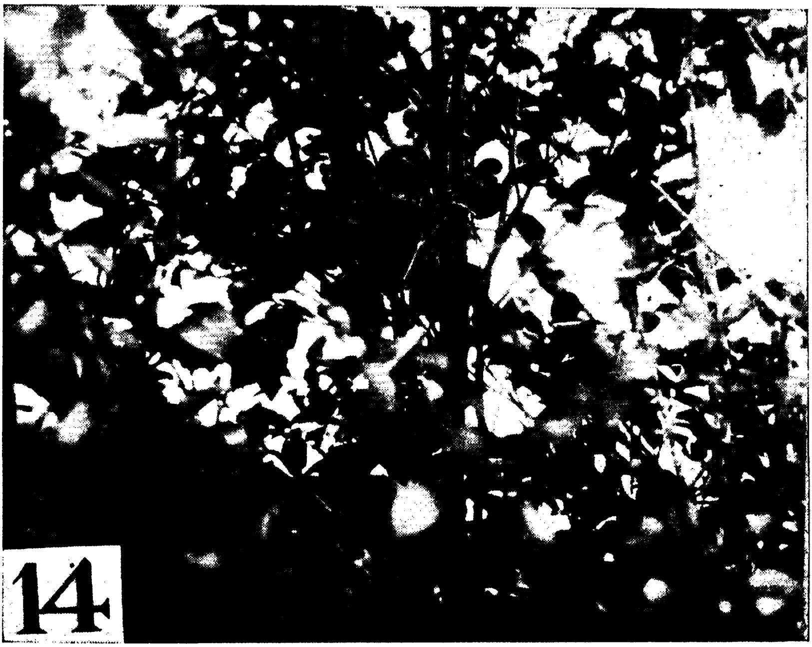
PLATE VIII.



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NITROGEN TRANSFORMATIONS IN THE DECOMPOSITION OF SUGAR-CANE TRASH, WITH SPECIAL BEARING UPON PUERTO RICO SOIL PROBLEMS.*-**

JUAN AMÉDÉE BONNET,
Research Chemist, Puerto Rico Insular Experiment Station.

INTRODUCTION

Sugar cane is the most important crop of Puerto Rico. As the area for sugar cane cultivation is limited, it has been necessary to increase the yields of tonnage and sucrose content in the sugar cane with the lowest possible cost. The 1910 production of the Island was 349,840 short tons of sugar. In that year, the Puerto Rico Sugar Growers' Association established an Experiment Station at Río Piedras, Puerto Rico, which in 1914 passed under government control. In its twenty years of active work attention has been given to various phases of tropical agriculture. Experimentation based on modern principles of soil science management has been applied to the cultivation of the sugar cane.

From 1911 to 1920, inclusive, the average production of the island was 414,426 short tons of sugar. During the last ten years the total production in short tons of sugar has been as follows:

1921	489,817	1926	606,464
1922	408,325	1927	630,202
1923	379,171	1928	751,332
1924	447,587	1929	586,760 *
1925	660,532	1930	872,326

The area under sugar-cane cultivation from 1915 to 1924 was between 203,105 to 256,431 acres. During the last years the area under cultivation has been, more or less, 242,000 acres. The 1930

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* Part of a thesis submitted on May 10, 1930 to the faculty of Rutgers University, New Brunswick, New Jersey, in partial fulfillment of the requirement for the degree of "Master in Science".

** The writer wishes to express his appreciation to Dr. Selman A. Waksman, who supervised the work, for the many valuable suggestions and criticisms offered throughout the experiment. The thanks of the writer also are due to Dr. Robert L. Starkey, for advice and help.

* Decrease due to hurricane of September 13, 1928.

crop showed an increase of 93.51 per cent over the 1924 crop. The application of soil science principles have been successful in saving many a sugar-cane grower from dreadful bankruptcy. New sugar-cane varieties, scientific applications of fertilizers, modern methods of field cultivation, and the proper use of machinery, irrigation, and drainage have been among the factors which contributed to the increase in the sugar-cane production of Puerto Rico to its present status.

THE ORGANIC MATTER PROBLEM

In the 1927–1928 report of the Insular Experiment Station of Puerto Rico, the present director, R. Fernández García says: (**8**)

> "It is our belief, as has been pointed out in previous reports, that the apparent degeneration of cane varieties as shown by their susceptibility to diseases and pests and their ever-decreasing yields is not a degeneration of the varieties but is due to unfavorable changes in the soil conditions brought about by our present agricultural practices.
>
> "Our inability to return to the soil, under present practices, the organic matter that is lost by tillage must necessarily not only lower the organic matter content of the soil but its quality and rate of decomposition. This continued loss of organic matter results in very unfavorable conditions for the plant and new varieties have to be imported or bred that will tolerate such conditions."

The organic matter of a soil is supplied by a great mass of substances of plant, animal, and microbiological origin. It is dynamic in nature and has a complex, variable composition. Its decomposition in the soil is mainly biological and greatly improves the chemical and physical properties of the soil.

Organic matter decomposition supplies the soil solution with carbon dioxide. The carbonated water renders soil nutrients soluble which can thus be taken by the higher plants. Organic matter improves the physical properties of the soil, such as, moisture-holding capacity, buffer effect, mineral absorption, temperature, etc., and introduces certain rare elements usually not brought in the organic fertilizers that may have some stimulating action on plant growth.

The additions of inorganic fertilizers to the soil supplies nutrients for the needs of the sugar-cane plant, but does not replenish the losses of organic matter. It requires a great outlay of money to supply organic matter to the soils with applications of organic commercial fertilizers. It has been economically advisable in many occasions to use green manure crops as a source of organic matter. It has been found also advisable to incorporate to the soil the straw which is left as waste in the wheat and sugar-cane fields.

The nitrogen added to the soil in the form of organic fertilizers

or organic residues is not present in an available form. It is this property which makes them frequently very valuable, especially, in wet districts. The nitrogen is not readily washed out and is gradually made available to the plant in the course of time. The addition of organic matter furnishes certain organic compounds which are used for structural and energy purposes by the non-symbiotic nitrogen fixing organisms. Leguminous plants serve as a host for the symbiotic nitrogen fixing organisms.

The physical condition of the heavy clay soils which are so common in the sugar-cane fields are greatly improved by the addition of undecomposed organic matter. The carbon dioxide produced in the decomposition processes makes the heavy soils more porous. It is more advisable to apply organic matter after it has been partly decomposed, to sandy soils. Under these conditions the coarser particles will be cemented by the colloidal "humus".

There is sufficient evidence to justify the belief that another important use of the organic matter is to supply during its decomposition certain compounds partially synthesized for the use of the plant. Knudson (**10**) showed in Cornell that corn absorbs and assimilates glucose, fructose, saccharose and maltose. It is not illogical to expect similar results from the use of amino acids and other products of protein decomposition.

The conservation of soil organic matter must be studied in relation to the plant, the soil and its microbiological population.

Some workers have associated the phenomenon of organic matter decomposition in soils with that of "denitrification". When such a nitrate reduction process goes to completion, nitrogen is lost in a gaseous form, either, as atmospheric nitrogen or as oxides of nitrogen. This concept made many farmers regard the addition of organic matter to their soils as an undesirable process.

Denitrifying organisms are active largely under anaerobic conditions. It is favored by excess of water and organic matter. When a solution of certain nitrate salts is inoculated with denitrifying organisms losses of nitrogen are observed. Such a phenomenon occurs in the soil in an entirely different way. When a soil is not too moist there could be partial reduction of nitrate salts to nitrite and ammonium salts without the reduction going further to gaseous nitrogen. As soon as the soil conditions favor the activity of the nitrifying organisms the ammonium salts will be reoxidized to nitrite and nitrate salts. The conclusion may be reached that the phenomenon of denitrification is of no economic significance in well aerated, not too moist soils, in the presence of moderate amounts of organic matter.

Under normal field conditions, usually, the nitrogen is transformed to less available organic forms by the microorganisms concerned with the decomposition processes of organic matter which need available nitrogen for building their cell protoplasm. In course of time the nitrogen is made again available. In the process of cell building the microorganisms compete with the plant for the available nitrogen. The carbon-nitrogen ratio of the organic material under decomposition is of special importance in this connection. It has been shown that there exists a more or less constant ratio between the nitrogen and carbon content of the soil, whatever the ratio was between these elements in the organic matter originally added to the soil. This ratio varies from 1 : 8 to 1 : 12, i. e., for every part of nitrogen there exists in the soil eight to twelve parts of carbon; the average ratio is about 1 : 10.

There is no appreciable effect upon the soil nitrate if the nitrogen of the organic matter added is about 1.8 per cent. (**18.**) A higher nitrogen content allows a rapid accumulation of ammonia and nitrate in the soil. Such is the case when dried blood, cotton seed meal, urea of other organic material with a high nitrogen content, and therefore, with a narrow nitrogen-carbon ratio is added to a normal soil. When the nitrogen-carbon ratio of the soil is wider than normal, plant growth suffers and nitrogen starvation will be observed as long as the excess of carbon lasts, since the microorganisms using the carbon as a source of energy will assimilate every trace of nitrogen that would otherwise be utilized by the higher plants.

As straw and sugar-cane trash have nitrogen-carbon ratios as wide as 1 : 80 it would not be advisable to incorporate such materials to a nitrogen starving soil unless nitrogen is supplied. If the sugar-cane trash is allowed to decompose a few weeks previous to planting, nitrogen starvation of the plant is not so noticeable.

Soil microorganisms may obtain their nitrogen from protein and their degradation products or simple inorganic nitrogenous compounds, including the ammonium salts and nitrates. Some organisms, especially the heterotrophic bacteria, prefer and many even require complex proteins, albumoses or peptones as a source of nitrogen (and energy), while other microorganisms, especially the fungi and autotrophic bacteria, will thrive just as well and sometimes even better upon simple compounds of nitrogen. The minerals, chiefly phosphates and potassium salts, but also iron, magnesium, sulphur, calcium and traces of other elements, are utilized by all microorganisms either in the form of simple inorganic compounds or are obtained from complex organic substances in the process of their decomposition. The mine-

rals may often be obtained from insoluble inorganic materials, especially if the organism produces acids which tend to make them soluble.

Temperature and moisture conditions in the tropics accelerate organic matter decomposition because they favor the activities of a group of soil microorganisms (heterotrophic) capable of breaking organic substances to use the carbon and free energy for their metabolic needs. The action of such microorganisms may be direct or through the agencies of enzymes. The protein nature of the microorganism protoplasm furnishes sources of proteins further decomposed by fungi and bacteria through polypeptides, amino acids and ammonium salts. The oxidation of the ammonium through the nitrite and nitrate stages furnishes energy for the activities of the nitrifying organisms. The sugars liberated in organic matter decomposition furnish energy for the non-symbiotic nitrogen fixers.

As organic matter is essential for microbiological life it is necessary to supply it to the soil, at intervals. If this is not done, a great part of the soil organic matter will be wasted as carbon dioxide into the atmosphere.

SUGAR CANE TRASH

The great bulk of the organic matter in the sugar cane fields is furnished by the leaves, leaf sheaths and tops of the sugar cane plant, which, in the form of trash are left in the field. Most of the green tops are used as fodder for farm animals. Dead roots contribute a small part. Maxwell (**13**) reports in 1898 an average of 33 per cent of total trash per ton of cane per acre for the Hawaiian crop. The weight of roots was considered to be very small, namely, about 4 per cent. (**14**.)

The bulkiness of the trash interferes with the crop cultivation. The most rapid method of getting rid of it is by burning. Sometimes this is done as a means to cut down field expenses. The trash is burnt either before or after cutting the crop. Claim is made that fire does not injure the following crop in its germination power and that injurious insects are destroyed.

Burning off destroys the borer parasite, but not always the borer. (**13**.) The borer is usually sheltered in the rotten cane left on the land which protects the insect from the fire effects. In 1916, Wolcott (**30**) reported that burning off increases borer infection 100 per cent.

Studies have been made on the effect of fire on tonnage and sucrose yield when the harvest is delayed for a few days. López Domínguez (**11**) in Puerto Rico experimenting with Cristalina and P.R.–209 canes found that when subjected to fire while standing in

the fields, or if stored, the canes lost about 2 per cent of their original weight per day. The loss in weight caused by delayed milling was greater in the burned canes than in the unburned ones. The burned cane suffered inversion both when cut and when left standing in the field, but the standing cane suffered greater losses in sucrose than the cut cane. At the Ewa Plantation, (**20**) Hawaii, H-109 harvested five, ten, fifteen days after burning, lost respectively; 14.72 per cent, 29.7 per cent and 20.29 per cent, of the original weight. Burned cane cut at once and burned cane allowed to stand until milled differed little in sugar losses. Alincastre (**3**) says:

"Cane burning before cutting permits loss of sap and decomposition by microorganisms. Losses occur after 24 hours which offset the decreased harvesting cost."

O'Brien (**16**) also condemns this practice.

In Puerto Rico, a few plantations burn the trash when harvesting the ratoons. Most manage to handle the trash during the cultivation of the ratoons; but when the land is to be prepared for a new crop the field is cleaned by means of fire. In the irrigated fields of a certain large plantation the trash is burned. In their non-irrigated fields the usual custom for fall-planting is to leave the trash on the ground while preparing the field, raking it to one side and spreading it over after the planting is made. With spring planting, they always burn the trash. When there is too much straw while the ratoons are under cultivation it is the usual custom to bury part of the straw in the rows.

In the low lying lands of some plantations located at the western section of Puerto Rico, large amounts of trash are moved about by the floods and deposited in heaps. It is expensive to handle the piles of mud and trash. So; in these fields, trash is usually burned.

The following comments on sugar cane trash are taken from the report (**12**) presented by the Puerto Rico delegates on the 1927 International Meeting of Cane Technologists held at Havana:

Taggard, Louisiana:

"As trash buried at a great depth does not decompose, beneficial effects such as: addition of organic matter, improvement of soil physical conditions and addition of inorganic nutrients to the soil, are not obtained. For this reason in Louisiana the trash is slightly covered with soil."

Moir, Hawaii:

"The practice in Hawaii is to burn the trash. So far no evil effects have been observed in the soil."

Agee, Hawaii:

"The roots that remain in the soil are sufficient to maintain the organic matter equilibrium in the soil."

Menéndez Ramos, Cuba:

"The most beneficial effect from the trash is the preservation of soil moisture and checking of weeds growth. The mulch effect is of more value than the fertilizer nutrients added to the soil."

It was also reported:

"In Cuba, the yields per acre were higher in certain fields where the trash was burned. This was attributed to the fact that no cultivation was given to the fields where the trash was left; while those where the trash was burned were carefully cultivated. Borer infection was higher where the trash was burned."

Storey, South Africa:

"Experiments were made with Adco and trash, to convert the latter into humus. The trash must be left moist. Trash was converted into humus in three months during the summer."

López Domínguez and del Valle (**12**) summarize those statements as follows:

"The results in Cuba indicate that it would have been better to cultivate the soil and line the trash. As to the non-evil effects observed in Hawaii from burning the trash, it must be considered that the Hawaiian soils are very porous, and that cane in Hawaii has been an important commercial crop for the last twenty-five years only. In Louisiana, where cane is grown since the 17th. century in alluvial soils heavier than those of Hawaii and where field methods have been carefully studied, it is not burned. In Puerto Rico with its heavy soils under cultivation for several generations and where the borer exists, the trash should not be burned. Means must be studied to handle the trash in the most economical way which at the same time is the most beneficial to the fields. The questions to be answered are: Is the trash to be buried or left over the surface? Must the trash be lined or spread over the whole surface?"

The increase in sugar cane yield in a field where trash is burned as has been observed in Cuba and Hawaii may be due to a partial sterilization effect whereby the nutrients are rendered more available for the use of the crop. It is a temporary effect which may last till the soil exhausts its natural supplies. Part of the available minerals accumulating on the porous soils of Hawaii after the trash is burned may be lost through leaching.

Agee's comment was reported in 1924 by Mc. George (**15**) as follows:

"To determine if the current practice of burning the trash in the Hawaiian islands, was depleting the organic carbon of plantation soils, 42 samples of Ewa soils representing cultivated and uncultivated portions of nine fields, were analyzed for total carbon content (little or no carbonate carbon being present in coral soils.) In these fields the organic content in four was lower, and in five higher, in the cultivated than in the uncultivated portions. The variations were, for cultivated fields, from 0.85 to 1.93 per cent with an average of 1.30 per cent and, for the uncultivated, from 0.74 to 2.60 per cent with an average or 1.37 per cent. In these fields the trash is always burnt, and there appears to be no indication that there is any depletion of the organic carbon content, the roots and stubble presumably being sufficient for keeping it up."

Such results, however, could not be considered as significant unless proved to be so, by statistical methods. De Turk (**7**) says:

"The variability of field soils makes the problem of determining increases in organic matter brought about by a treatment a difficult one, requiring great care in selecting similar pairs of plots for comparison. It was assumed that composites made up of twelve borings would give samples sufficiently representative of the soil of the plots. The probable error for 12 borings was 0.76 per cent of the mean or 50 to 450 pounds of organic carbon per acre."

The results obtained with the Adco treatment may also be obtained if the proper compost is prepared by adding a mixture of fertilizer salts to the trash. Adco, is a mixture of fertilizer salts that serve as a supply of nutrients for microorganisms. The compost is prepared by adding 150 pounds of Adco to a ton of straw. Sufficient water is added to make about three tons of manure. The question to be settled is whether or not the Adco treatment is economical. In the preparation of an adequate manure Albrecht (**2**) recommends:

"A mixture consisting of 45 pounds of ammonium sulphate, 15 pounds of acid phosphate, and 40 pounds of finely ground limestone at the rate of 150 pounds per ton of straw, will, with moisture, convert straw into a brown product having all properties of manures."

According to Noel Deerr: (**6**)

"It is the custom in Hawaii, Demerara, and Java to burn the trash. In Mauritius, much of the trash is used as bedding for the plantation stock and thus finds its way back to the soil as pen manure. A similar routine is followed in the British West Indies. In Cuba it is the almost invariable custom to let trash rot on the fields, where it remains as a blanket. To this custom the long continued fertility of the Cuban cane lands is to be attributed.

"During the period 1901–13 extensive experiments were made on a Hawaiian plantation, in all 109,990 tons of trash being buried."

The effect of this procedure is thus described: (**6**)

"Where two ratoons were formerly the maximum, four are now becoming the rule. The yields, instead of decreasing with each subsequent ratoon, have increased. The 1908 crop was the first one to have trash left over its entire ratoon area. That and the succeeding crops show an average yield of 4.102 tons of sugar per acre; the seven preceding crops gave 3.329 tons of sugar per acre. The 1914 crop to date has yielded 5.2 tons per acre and is expected to go still higher. While all the credit cannot be given to trash, there is no doubt whatsoever that leaving the trash has been the principal factor."

The actual operations in Hawaii followed on a rainfall plantation are described by Larsen: (**6**)

"After the cane is cut the trash is hoed away from the stools into the furrow. This work requires about two men per acre per day and is called 'pali-pali-ing'. This is followed by off-barring, which consists of ploughing off or away from the stools. The soil by this operation is thrown against and partly over the trash and assists materially in hastening its decay. A ten, twelve or fourteen-inch plough is used for off-barring. A revolving knife or sharp coulter is attached to the ploughbeam to make a clean cut ahead of the plough. One man with two mules can off-bar 2 to 2½ acres per day. After off-barring, hoeing is done in the cane lines. In the furrow, that is, between the lines of cane, the weeds in most cases are kept down effectively by the trash. Cultivation between the rows begins from one to two months after pali-pali-ing. After two or three more hoeings in the cane rows as occasion demands and as many more cultivations the trash will have become so thoroughly broken up and disintegrated that the furrow can be small-ploughed without trouble. A small eight-inch plough is run usually four times through the furrow to loosen up the soil and to mix in the trash. After small-ploughing, the cane is hilled. This is done with hoes, ploughs, double mould-boards, or discs. With this operation the rotted and partly rotted trash is thrown toward the cane and is more thoroughly buried and mixed with the soil."

In certain soils in Demerara the presence of decaying trash has, according to Harrison (**6**) a specific function in neutralizing the effect of the large quantity of alkaline soil water there present. On this point he writes:

"In experiments in which (*a*) soil water was allowed to evaporate into the air and (*b*) caused to evaporate in an atmosphere consisting almost entirely of free carbon dioxide it was observed that when the evaporation takes place in air, nearly free from carbon-dioxide gas, practically the whole of the lime salts are deposited as calcium carbonate, while the water is being concentrated to one-third of its original bulk, and the remaining water becomes a saline one, containing large quantities of magnesium salts as chlorides, sulphates and carbonates in solution. The calcium salts, which are known to exercise a profound influence in reducing the highly toxic action of the magnesium chloride and carbonate on plants, are almost wholly removed from solution and the soil water becomes in a condition which is poisonous to vegetation; this is probably what takes place during prolonged periods of dry weather or more or less worn-out cane soils, in which by injudicious cultivation and especially by long-continued destruction of

the trash by burning, the normal proportion of organic matter has been largely reduced. When, on the other hand, the evaporation takes place in an atmosphere heavily charged with carbon dioxide, as in the air present in soils containing the proportion of organic matter normal to good soils, the calcium salts remain for a long time in solution until the liquid commences to become a saturated brine, and this for a prolonged period continues to modify the toxic action of the magnesium salts. It is possible on such land that the soil water during drought may become concentrated in the upper layers of the soils, without any material injury to the plant, until by concentration of the soil water the toxic action of the magnesium salts exerts itself.''

Cross, (**5**) Director of the Tucuman Experiment Station, recommends the following procedure:

''It is practically feasible to leave the trash without burning, in every second middle, cultivating the other one, and every year to alternate the middle so treated. The soil benefits from the nitrogen and organic substances and the sugar yields are increased. The procedure is particularly recommended for plantations invaded by weeds.''

In 1914, in Hawaii, special rakes were prepared to handle the trash. (**1**.) Mr. F. E. Hance, acting chemist of the Hawaiian Sugar Planters Experiment Station, reports in a letter to the writer dated March 12, 1930:

''In Hawaii, no special implements are in use for handling the trash. The custom is to ripen the cane and burn the trash. In the winter time and at all times in some plantations trash remaining on the ground is ploughed under, if the field is to be replanted.''

Klinge (**9**) reports:

''Trash is burned in Hawaii as well as in Peru with the difference that in Hawaii the burning is done in situ and in Peru is done in the rows where the trash is piled after raking it from the field. After cutting the cane in some irrigated fields of Hawaii, the trash is raked towards every other furrow. The intermediate furrow is used for irrigation purposes. The practice of burning the trash followed by those plantations that only depend on rain water for cane growth is very variable. Some plantations burn the trash; while others leave it to rot in the soil. Complete burning cannot always be carried on when the continuous rains keep the trash moist. Under these conditions sufficient unburnt trash remains on the soil.''

In Java (**19**) trash is either transported to the factory to be used as fuel or is burned in the field as a means to clean the soil for the rice crop. It is the custom to get two successive rice crops after the sugar cane crop. Part of the rice straw is incorporated to the soil. The cane is never burned before cutting; special precautions are in fact taken against accidental fires by removing trash at least thirty feet away from nearby roads.

Owen (**17**) reported in 1926 on work done at the Louisiana Experiment Station:

"Adding undecomposed trash to the soil, resulted in a rapid loss of nitrates, but this depressing action upon nitrates disappeared rapidly with the trash decomposition. The addition of fresh trash caused a marked increase in the soil fungi and increased the ratio of fungi to total number of microorganisms. The depressing effect of trash upon the soil nitrates has been traced to the starch and pentose content of the material."

Bonazzi (**4**), on studies at the Chaparra Experiment Station, Cuba, referred particularly to the influence of the incorporation of sugar cane trash on the moisture content of soil:

"Greatest retention of moisture is to be obtained by allowing the cane leaves to accumulate on the surface of the land. Incorporating the leaves in the soil through ploughing or cultivation does not justify the additional expense. Denitrification is strongly active in presence of cane leaves incorporated with soil. When nitrates were applied in the form of sodium nitrate the losses were very large, whereas in the soils receiving easily assimilable carbohydrates, but no nitrate, the formation of a small quantity of nitrates from the natural soil stores of nitrifiable substance was followed by its early disappearance. The same path was followed by the soils receiving their nitrogen in the organic form.

"The formation of nitrates from tankage in soils containing cane leaves was not cumulative but reached a maximum aften ten days, followed by a rapid disappearance during the second period of incubation. This experiment indicates that great care should be taken not to incorporate cane leaves and trash in the soil at a time of active nitrate formation in the soil. Such a practice would prove deleterious to the growing cane."

A series of plot experiments at the Insular Experiment Station, Puerto Rico, was arranged as follows: (**8**)

(1) One and a-half tons air-dried chopped cane trash + 800 pounds $(NH_4)_2SO_4$ per acre.
(2) Treatment (1) + 2 tons $CaCO_3$ per acre.
(3) Check.
(4) One and a-half tons of cane trash + 2 tons $CaCO_3$ per acre.
(5) One and a-half tons of cane trash per acre.

The land was kept free from vegetation. The effect of cane trash on soil nitrates was followed for a period of 23 weeks. It was found that the addition of trash alone lowered the level of nitrate concentration in the soil. The addition of sulphate of ammonia to the trash raised the level of nitrate concentration to a maximum of eighty pounds per acre over the check in 21 weeks. The pH of the soil was 7.44. In the first treatment, nitrification was slower at the start; but from the eighth week on surpassed that of the second treatment.

In another series of plot experiments at the same Station, the equivalent of $1\frac{1}{2}$ tons of trash per acre was added to a clay soil and sown to soybeans. (**8**.) The gain in yield of this plot was 201 per cent ± 33 per cent over the check. Plots with loam soil given a gain in yield over checks of only 160 per cent ± 12 per cent. The same plots planted to BH-10(12) after incorporating the soybeans did not show such striking difference in yield.

Chemical studies of organic matter decomposition have been greatly based on determination of carbon, nitrogen, ash and loss by ignition. The loss in dry weight was also considered. Such analyses do not give information of what actually happens in the course of organic matter decomposition. To understand the decomposition of sugar cane trash in the soil it is important to gain information concerning the nature of the different groups that form the organic complex. The classification of the various chemical plant constituents into a series of definite groups as proposed by Waksman (**27**) is a great tool for the study of organic matter decomposition in the sugar cane fields. The various chemical plant constituents are divided into the following groups:

"1. *Water-Soluble Constituents.*—These include the most readily available nutrients, both for the growth of the plant and for the growth of microorganisms, when the plant is undergoing decomposition. These constituents comprise a number of organic and inorganic substances, such as the sugars, various glucosides, amino acids, and certain simple proteins among the former, while the latter includes nitrates, phosphates, sulphates, chlorides, potassium salts, etc. This group of plant constituents is highest when the plant is young, making up as much as 40 per cent of the dry matter of the total plant material. This percentage decreases with age, so that mature plants may contain only about 5 per cent of water-soluble constituents, these proportions depending of course also on the nature of the plant and available nutrients.

"2. *Ether and Alcohol-Soluble Constituents.*—They comprise the fats and oils, waxes and resins, tannins, terpenes, alkaloids, and various pigments. They make up only a small portion of the plant, usually 2 to 6 per cent.

"3. *Celluloses.*—These form in most plants the largest single group of constituents, ranging from 15 to 40 per cent of the dry weight of the plant material. They are polysaccharides which serves the function of protective substances in the plant and they are not hydrolyzed by dilute acids and alkalies. They are rapidly decomposed, however, under certain conditions by various specific bacteria and fungi.

"4. *Hemicelluloses.*—These and allied carbohydrates, not included in the sugars and in the celluloses, play a function of both reserve and protective substances in plants. They are also polysaccharides of the pentose or hexose group and are hydrolyzed by dilute acids. They make up 10 to 30 per cent of the plant constituents. Some of them are decomposed even more rapidly than the celluloses, while others are more resistant.

"5. *Lignins.*—Lignins are the so-called incrusting substances in plants. Both lignins and celluloses, which form in the plant complexes of a chemical or physical nature known as ligno-cellulose, are low in young plants and increase in proportion with the age of the plant, both in total quantity and in relation to the other plant constituents. The lignins, which make up 5 to 30 per cent of the dry plant material, are most resistant to decomposition in the soil.

"6. *Proteins.*—These substances play an important function in the nutrition of the plant and in the decomposition of the plant residues in the soil, since they are largely the carriers of the important element nitrogen, as well as of some of the phosphorus and sulphur. In view of the fact that the nitrogen is liberated in the form of ammonia, as a result of the decomposition of the proteins, it was usually assumed that it is sufficient to measure the rapidity of ammonia accumulation from protein decomposition in the soil. However, we come to recognize now that, in the presence of celluloses and hemicelluloses, which are readily used as sources of energy by microorganisms, a part, if not all, of the nitrogen which is liberated in the decomposition of the proteins may be reassimilated by the soil microorganisms and changed into microbial cell substances. The nitrogen (or protein) content of plants is high at an early stage of growth and decreases with an increase in the maturity of the plants, frequently from 18 per cent protein in the young plants to about 1.2 to 1.5 per cent in the mature straw.

"7. *Minerals.*—These include phosphates, sulphates, chlorides, nitrates, and silicates of potassium, calcium, magnesium, iron, aluminum, etc., some of which are water-soluble and others insoluble. They form the ash content of the plant, although some are also present in the proteins (S, P). They make up from 1 to 12 per cent of the total plant constituents. They are high in young plants and diminish, in proportion to the other plant constituents, with maturity of the plants. The nature of the minerals in the young and old plants differs not only quantitatively but also qualitatively, the soluble minerals predominating in the younger plants and the insoluble in the other plants.

"In these seven groups of complexes we can account for practically 90 to 96 per cent of the plant constituents."

EXPERIMENTAL

COMPOSITION OF SUGAR-CANE TRASH

Analyses were made of two samples of trash which were used in subsequent experiments. The first sample was obtained from a field of POJ–2714, adjoining the United States Field Station at Canal Point, Florida.* It was gathered from the soil surface around cane in the dry form and was further sundried before shipment. The second sample of sugar cane trash was taken at the Everglades Experiment Station, Florida,* as dead leaves from the lower part of the stems of SC–12(4). Before shipping, it was thoroughly dried in the greenhouse. The samples were ground in a No. 1 Wiley mill and sifted through a 1mm. sieve.

* Thanks are extended to Dr. B. A. Bourne, Canal Point, and Dr. R. V. Allison, Everglade Experiment Station for furnishing the samples of sugar-cane trash.

The approximate complete analysis of the sugar-cane trash was carried in duplicate as follows:

Moisture, total nitrogen and ash.

Six-gram portions were analyzed as follows: (**29**)

(*a*) Extracted with ether in Soxhlets for 16 hours.

(*b*) Residue was extracted for 24 hours with 100 cc. of cold water.

After filtering, the residue was washed several times with cold water. The filtrate was made to volume and divided into three portions, one used for reducing sugar, one for total nitrogen after evaporating excess of water and one for total soluble organic matter by evaporating and drying to constant weight. Ash determinations were carried on after igniting the organic matter.

(*c*) Residue from (*b*) was treated for 3 hours with 100 cc. of hot water over boiling water bath. The solution was analyzed as in (*b*).

(*d*) Residue from (*c*) was treated twice with 100 cc. of 95 per cent alcohol.

The flask was placed for 2 hours on a boiling-water bath. The filtrate and washings were evaporated to constant weight. The difference between the weight of the paper with the residue and that of the original paper gives the weight of the plant material from which the ether and water-soluble, as well as the alcohol-soluble portions have been removed.

The sum of the weight of fractions (*a*), (*b*), (*c*) and the weight of the plant substance left after the alcohol extraction was taken as the quantity of the original dry plant material taken for analysis. All calculations were based on such weight.

(*e*) The residue from (*d*) was treated with 100 cc. of a 2 per cent solution of hydrochloric acid and autoclaved for five hours under flowing steam. The solution was filtered off through dried and weighed filter papers. The residue was washed with dilute acid and then with water until free from acid. The filtrate and washings were analyzed for reducing sugars by the Bertrand method, and for total nitrogen. The hemicellulose content was obtained multiplying the reducing sugars by 0.9.

(*f*) The washed residue from the hydrochloric acid extraction was dried to constant weight. Two 1-gram portions of the dry material were treated with 10 cc. of 80 per cent sulphuric acid, for 2 hours, in the cold. The acid was brought in contact with all particles of the material by stirring. After 2 hours, 150 cc. of distilled water were added to each treatment and the contents were autoclaved for 1 hour at

15 pounds pressure. The contents were filtered through small dried and weighed filter papers. The residue was well washed with water to free from traces of sulphuric acid. The combined solution and filtrate was analyzed for reducing sugars. The cellulose content was obtained multiplying the reducing sugars by 0.9. Of the four residues for each original material, two were used for ash and two for nitrogen determinations. Weight of residue —(ash + nitrogen × 6.25) = lignin content. The cellulose and lignin found in the one gram portion of residue left after the 2 per cent HCl extraction was multiplied by the weight of this residue to obtain the cellulose and lignin content in the original 6 grams of material.

TABLE I

COMPOSITION OF OVEN DRIED SUGAR CANE TRASH

Chemical Constituents	Sample No. 1 POJ-2714 per cent	Sample No. 2 S. C. 12–4 per cent
Ether soluble Fraction	2.34	1.85
Cold Water Soluble Organic Matter	4.42	1.92
Hot Water Soluble Organic Matter	2.17	1.56
Alcohol Soluble Fraction	.56	1.25
Hemicelluloses	25.33	26.32
Celluloses	29.71	32.85
Lignin (nitrogen & ash free)	11.53	16.06
Water insoluble protein	2.00	2.25
Total Ash	12.79	6.30
Totals	90.85	90.3

The total nitrogen contents by the Kjeldahl method were 0.59 per cent and 0.64 per cent for samples 1 and 2, respectively. The total carbon contained in the first sample was 40.3 per cent as determined by a wet method (**23**) using $KMnO_4$ as the oxidizing agent. The pentosan content of the same sample was 25.21 per cent as determined by furfural distillation with 12 per cent HCl and precipitation with phloroglucinol. Total carbon and pentosans were not determined on the second sample. There were no reducing sugars in the water extracts of either sample of trash.

DECOMPOSITION OF SUGAR-CANE TRASH

Trash sample No. 2 (SC–12–4) was used in this experiment. It was chopped in pieces about ½ inch in size. Twenty grams portions in each of 12 one-liter flasks were inoculated with 1 cc. of soil infusion (10 grams of soil to 100 cc. of tap water). Enough water was added

to give composts containing 66, 80 and 88 per cent of water. The treatments were as follows:

1 and 2..............66 per cent water
3 and 4..............66 per cent water + 1 gm. $(NH_4)_2SO_4$
5 and 6..............80 per cent water
7 and 8..............80 per cent water + 1 gm. $(NH_4)_2SO_4$
9 and 10..............88 per cent water
11 and 12..............88 per cent water + 1 gm. $(NH_4)_2SO_4$

One set was incubated for thirty days at 28°C and a second set for sixty days before analyses were made. Tests for moisture, nitrates, ammonia and total nitrogen were made on the wet decomposed material. Nitrates were determined by the phenoldisulphonic acid method. Ammonia was extracted with normal KCl and determined by distillation with magnesium oxide. Total nitrogen was determined by the Kjeldahl method.

The analysis of the organic constituents was performed on 6-gram portions of the material after drying at 40°C. The procedure previously described was followed with one exception; no cold water treatment was given.

TABLE II

DRY WEIGHT LOSSES OF SUGAR CANE TRASH COMPOSTED FOR 30 AND 60 DAYS WITH OR WITHOUT ADDITIONAL INORGANIC NITROGEN

Days	Original Material	66 per cent Water		80 per cent Water		88 per cent Water	
		No nitrogen added	Nitrogen added*	No nitrogen added	Nitrogen added*	No nitrogen added	Nitrogen added*
	gm.	gm.	gm.	gm.	gm.	gm.	gm.
30	20	17.9	14.9	17.4	15.9	18.2	14.8
60	20	16 4	14.9	16.4	13.6	14 8	13.2

* Figures represent dry weight of residual material plus residual dry weight of $(NH_4)_2SO_4$ added.

The information given in terms of dry weight losses is of limited value unless we consider the fate of the different groups which constitute the sugar-cane trash complex.

TABLE III

COMPOSITION OF SUGAR CANE TRASH COMPOSTED FOR 30 DAYS WITH OR WITHOUT ADDITIONAL INORGANIC NITROGEN

Chemical Constituents (1)	Original Material	66 per cent Water		80 per cent Water		88 per cent Water	
		No nitrogen added	Nitrogen added	No nitrogen added	Nitrogen added	No nitrogen added	Nitrogen added
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Ether soluble fraction	1.85	1.08	1.57	1.05	1.18	0.89	1.04
Hot and cold water soluble organic matter (2)	3.48	3.39	7.48	4.14	6.68	2.94	5.59
Alcohol soluble fraction	1.24	1.37	2.29	1.55	2.39	1.45	2.34
Hemicelluloses	26.32	24.17	20.32	24.19	20.86	23.91	20.32
Celluloses	32.85	31.33	23.49	30.90	23.26	32.29	22.65
Lignin (nitrogen and ash free)	16.06	18.10	20.31	19.35	21.19	18.33	21.22
Water insoluble protein	2.25	3.06	7.44	3.56	5.94	3.81	9.44
Nitrogen as ammonia	0.00	0.00	0.83	0.00	0.75	0.00	0.75
Total ash	6.30	6.86	9.29	7.40	9.64	7.12	9.16
Totals	90.35	89.36	93.02	92.14	91.89	90.74	92.53

TABLE IV

COMPOSITION OF SUGAR CANE TRASH COMPOSTED FOR 60 DAYS WITH OR WITHOUT ADDITIONAL INORGANIC NITROGEN

Chemical Constituents (1)	Original Material	66 per cent Water		80 per cent Water		88 per cent Water	
		No nitrogen added	Nitrogen added*	No nitrogen added	Nitrogen added	No nitrogen added	Nitrogen added
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Ether soluble fraction	1.85	1.22	1.51	1.12	1.30	0.86	1.18
Hot and cold water soluble organic matter (2)	3.48	3.80	7.30	3.48	6.69	3.88	6.57
Alcohol soluble fraction	1.24	1.02	1.88	1.02	1.80	1.14	1.63
Hemicelluloses	26.32	24.35	19.33	24.24	18.78	22.29	19.39
Celluloses	32.85	27.68	17.49	30.64	17.61	27.65	18.12
Lignin (nitrogen and ash free)	16.06	19.13	22.41	19.44	22.81	19.88	24.41
Water insoluble protein	2.25	5.13	8.63	4.81	10.19	5.81	11.75
Nitrogen as ammonia	0.00	0.00	0.70	0.00	0.79	0.00	0.77
Total ash	6.30	8.52	9.78	7.76	10.42	8.24	10.94
Totals	90.35	90.85	89.03	92.51	90.39	89.75	94.66

(1)—All calculations on residual material dried at 100° C.
(2)—Water soluble organic nitrogen included.

Results as expressed in Tables III and IV are of a relative value; since the dry weight of the original material does not remain constant during the decomposition processes. Results in terms of actual weight as expressed in Tables V and VI give a much better information of the fate of the chemical constituents during the decomposition processes.

TABLE V

TOTAL CONCENTRATION OF THE CHEMICAL CONSTITUENTS OF SUGAR CANE TRASH COMPOSTED FOR 30 DAYS WITH OR WITHOUT ADDITIONAL NITROGEN

Chemical Constituents	Original Material (20 gms)	66 per cent Water		80 per cent Water		88 per cent Water	
		No nitrogen added	Nitrogen added	No nitrogen added	Nitrogen added*	No nitrogen added	Nitrogen added
	gm.	gm.	gm.	gm.	gm.	gm.	gm.
Ether soluble fraction	0.370	0.193	0.234	0.183	0.187	0.162	0.154
Hot and cold water soluble organic matter	0.696	0.608	1.115	0.720	1.062	0.535	0.828
Alcohol soluble fraction	0.248	0.245	0.341	0.270	0.380	0.264	0.346
Hemicelluloses	5.264	4.326	3.028	4.209	3.317	4.352	3.007
Celluloses	6.570	5.608	3.500	5.377	3.698	5.877	3.352
Lignin (nitrogen and ash free)	3.212	3.240	3.026	3.367	3.369	3.336	3.141
Water insoluble protein	0.450	0.548	1.109	0.619	0.944	0.693	1.397
Nitrogen as ammonia	0.000	0.000	0.124	0.000	0.119	0.000	0.111
Total ash	1.260	1.228	1.384	1.288	1.533	1.296	1.356
Totals	18.070	15.996	13.861	16.033	14.609	16.515	13.692

TABLE VI

TOTAL CONCENTRATION OF THE CHEMICAL CONSTITUENTS OF SUGAR CANE TRASH COMPOSTED FOR 60 DAYS WITH OR WITHOUT ADDITIONAL NITROGEN

Chemical Constituents	Original Material (20 gms)	66 per cent Water		80 per cent Water		88 per cent Water	
		No nitrogen added	Nitrogen added	No nitrogen added	Nitrogen added	No nitrogen added	Nitrogen added
	gm.	gm.	gm.	gm.	gm.	gm.	gm.
Ether soluble fraction	0.370	0.200	0.225	0.184	0.177	0.127	0.156
Hot and cold water soluble organic matter	0.696	0.623	1.088	0.571	0.910	0.574	0.867
Alcohol soluble fraction	0.248	0.167	0.280	0.167	.245	0.169	0.202
Hemicelluloses	5.264	3.993	2.880	3.975	2.554	3.299	2.558
Celluloses	6.570	4.540	2.606	5.025	2.395	4.092	2.391
Lignin (nitrogen and ash free)	3.212	3.137	3.339	3.188	3.102	2.942	3.222
Water insoluble protein	.450	.841	1.286	.789	1.386	.860	1.551
Nitrogen as ammonia	0.000	0.000	0.104	0.000	0.107	0.000	0.102
Total ash	1.260	1.397	1.457	1.273	1.417	1.220	1.444
Totals	18.070	14.898	13.265	15.172	12.293	13.283	12.493

Tables VII and VIII give the per cent of each of the original groups left after composting for thirty and sixty days.

TABLE VII

RESIDUAL MATERIAL OF THE VARIOUS CHEMICAL CONSTITUENTS OF SUGAR CANE TRASH COMPOSTED WITHOUT THE ADDITION OF NITROGEN

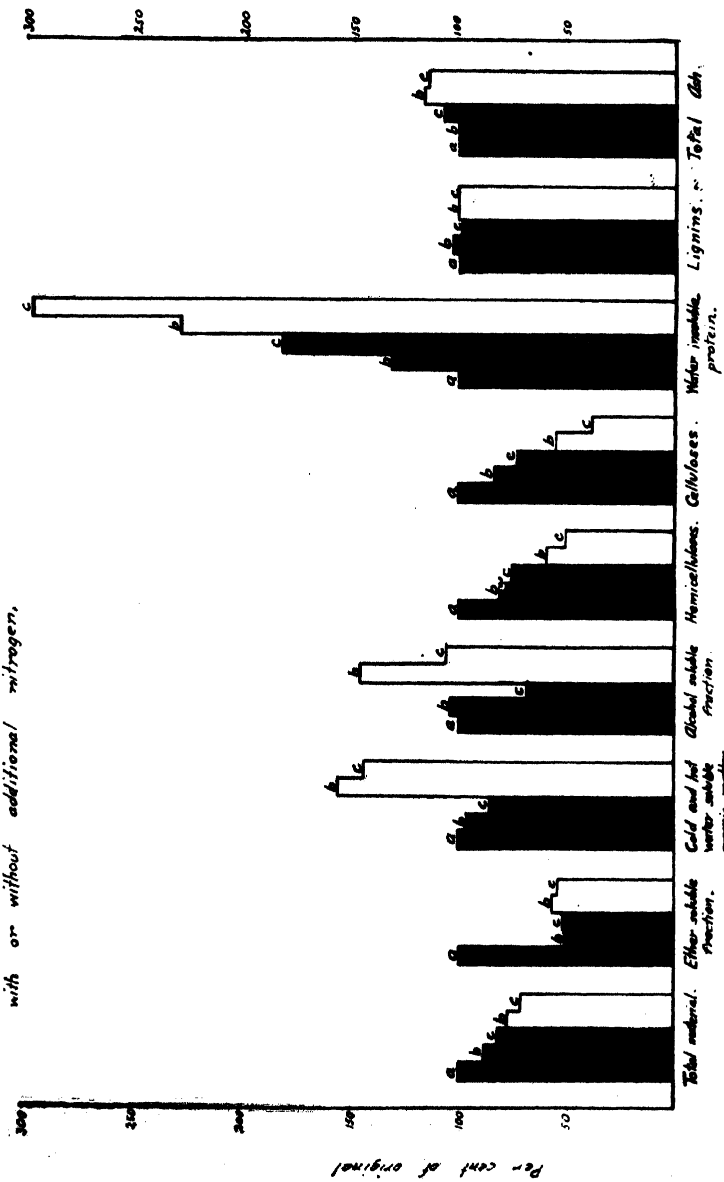
	Original Material	66 per cent Water		80 per cent Water		88 per cent Water	
		30 days	60 days	30 days	60 days	30 days	60 days
	gm.	Per cent of original	Per cent of original	Per cent of original	Per cent of original	Per cent of original	Per cent of original
Total dry material	20.00	89.50	82.00	87.00	82.00	91.00	74.00
Ether soluble fraction	0.370	52.16	54.05	49.46	49.73	43.79	34.32
Cold and hot water soluble organic matter	0.696	87.36	89.51	103.45	82.04	76.87	82.47
Alcohol soluble fraction	0.248	98.79	67.34	108.87	67.34	106.45	68.15
Hemicelluloses	5.264	82.18	75.85	79.96	75.51	82.67	62.67
Celluloses	6.570	85.36	69.10	81.84	76.48	89.45	62.28
Lignins (nitrogen and ash free)	3.212	100.87	97.67	104.83	99.25	103.86	91.59
Water insoluble protein	0.450	121.78	186.89	137.56	175.33	154.00	191.11
Total ash	1.260	97.46	110.87	102.22	101.03	102.86	96.83

TABLE VIII

RESIDUAL MATERIAL OF THE VARIOUS CHEMICAL CONSTITUENTS OF SUGAR CANE TRASH COMPOSTED WITH THE ADDITION OF NITROGEN

	Original Material	66 per cent Water		80 per cent Water		88 per cent Water	
		30 days	60 days	30 days	60 days	30 days	60 days
	gm.	Per cent of original	Per cent of original	Per cent of original	Per cent of original	Per cent of original	Per cent of original
Total dry material	20.00	74.50	74.50	79.50	68.00	74.00	66.00
Ether soluble fraction	0.370	63.24	60.81	50.54	47.84	41.62	42.16
Cold and hot water soluble organic matter	0.696	160.21	156.32	152.59	130.75	118.97	124.57
Alcohol soluble fraction	0.248	137.50	112.90	153.23	98.79	139.52	81.45
Hemicelluloses	5.264	57.52	54.71	63.01	48.52	57.12	48.59
Celluloses	6.570	53.27	39.07	56.29	36.45	51.02	36.39
Lignins (nitrogen and ash free)	3.212	94.21	103.95	104.89	96.58	97.79	100.31
Water insoluble protein	0.450	246.44	285.78	289.78	308.00	310.44	344.67
Total ash	1.260	109.84	115.63	121.67	112.46	107.62	114.60

Aerobic decomposition of sugar cane trash composted for 30 and 60 days with or without additional nitrogen.



a. Original material; b. Left after 30 days; c. Left after 60 days.
Black area - no nitrogen added. White area - nitrogen added.

The rate of conversion of the available forms of nitrogen into less available forms of nitrogen constituting the cells of microorganisms active in the decomposition processes is shown in Tables IX and X

TABLE IX

"NITROGEN TRANSFORMATION IN THE DECOMPOSITION OF SUGAR CANE TRASH"

(In per cent of total residual material)

Form of Nitrogen		No Nitrogen Added							Nitrogen Added					
		66% Water		80% Water		88% Water			66% Water		80% Water		88% Water	
	0 days	30 days	60 days	30 days	60 days	30 days	60 days	0 days	30 days	60 days	30 days	60 days	30 days	60 days
Total nitrogen	.64	.68	.92	.70	.86	.76	1.06	1.70	2.25	2.25	2.08	2.46	2.30	2.67
Nitrogen as ammonia	0	0	0	0	0	0	0	1.06	.83	.70	.75	.79	.75	.77
Soluble in hot and cold water	.28	.12	.10	.13	.09	.15	.13	....	.93	.87	1.07	.83	.79	.79
Hydrolyzable by 2 per cent HCl	.12	.19	.26	.24	.26	.23	.38	....	.43	.61	.47	.70	.52	.73
"Humin" nitrogen, not acted by autoclaving with 6 per cent H_2SO_4	.22	.22	.29	.25	.28	.26	.36	....	.37	.44	.37	.49	.42	.49

TABLE X

TOTAL CONCENTRATION OF THE NITROGEN TRANSFORMATION OF SUGAR CANE TRASH DECOMPOSING FOR 30 AND 60 DAYS AT DIFFERENT MOISTURES, WITH AND WITHOUT ADDITIONAL NITROGEN

Form of Nitrogen		No Nitrogen Added							Nitrogen Added					
	Original material 20 gms.	66% H_2O		80% H_2O		88% H_2O		Original material 20 gms.	66% H_2O		80% H_2O		88% H_2O	
		30 days	60 days	30 days	60 days	30 days	60 days		30 days	60 days	30 days	60 days	30 days	60 days
	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.
Total Nitrogen	128	122	151	122	141	138	157	340	335	335	331	335	340	352
Nitrogen as ammonia	0	0	0	0	0	0	0	212	124	104	119	107	111	102
Soluble in cold and hot water	56	21	16	23	15	27	22	....	138	130	170	113	117	104
Hydrolyzable by 2 per cent HCl	24	34	33	42	43	42	34	....	64	91	75	95	77	96
"Humin" nitrogen, not acted by auclaving with 6 per cent H_2SO_4	44	39	48	44	46	47	38	....	55	66	59	67	62	65

DECOMPOSITION OF CANE TRASH AS MEASURED BY THE EVOLUTION OF CARBON DIOXIDE

The decomposition of cane trash as measured by the evolution of carbon dioxide with or without the addition of minerals was studied in three different soil types brought from Puerto Rico by special permission of the United States Quarantine Board. These soils were among the first ones classified in the Soil Survey of Puerto Rico

which started in the fall of 1928 under the supervision of the United States Bureau of Soils. The types are:

1. Río Piedras clay. This type belongs to the Río Piedras series, deep phase. It is typically developed on the hills of the Puerto Rico Insular Experiment Station. The sample was taken at Km. 2.25 Leprocomio road, Trujillo. This soil is used for sugar cane and other crops.
2. Bayamón clay loam. This type belongs to the Bayamón series. It is strongly acid. The sample was taken at Km. 2.2, Sanatorium Road, Río Piedras. This soil is mainly used for citrus, sugar cane and other crops.
3. Múcara clay. It has the characteristics of Río Piedras clay but is higher in organic matter content. The sample was taken at Km. 2.8 Carolina–Juncos Road. This soil is used for sugar cane and other crops.

The Río Piedras clay and Bayamón clay loam are types representing poor sugar-cane soil. The Múcara clay represents a better sugar-cane soil.

All the soil samples were taken to a depth of six inches in a suitable place in the field. They were air-dried and sifted through a 2mm. sieve. The soils were free from carbonates.

To a duplicate set of seven 300 cc. Florence flasks the following materials were added:

(1) Trash.
(2) Trash + $(NH_4)_2HPO_4$ + K_2HPO_4.
(3) Trash + $NaNO_3$ + K_2HPO_4.
(4) Soil.
(5) Soil + trash.
(6) Soil + trash + $(NH_4)_2HPO_4$ + K_2HPO_4.
(7) Soil + trash + $NaNO_3$ + K_2HPO_4.

The first three treatments were inoculated with 1 c. c. soil infusion prepared by adding 100 c.c. of tap water to 10 grams of a rich soil (Sassafras sandy loam). The amount of trash added represented 5 grams of the dry material. Ground trash sample No. 1 (POJ-2714) was used. It was kept at optimum moisture by adding 200 per cent of its own dry weight as water.

The amount of soil used represented 100 grams of dry soil. Water was added to bring the moisture content up to 25 per cent. The equivalent of 42.3 mgm. of nitrogen and 100 mgm. of K_2HPO_4 were added as mineral sources. The complete set was connected to a carbon dioxide apparatus, as described by Waksman and Starkey. (**24.**)

The carbon dioxide given off was collected in one-sixth normal $Ba(OH_2)$. The excess of barium hydroxide was titrated back with one-sixth normal oxalic acid to determine the carbon dioxide absorbed, using phenolphthalein as an indicater. The experiment lasted 28 days. The system was aerated daily for four hours. Titrations were made every day during the first week and every other day, afterwards. Analyses for pH, nitrate and ammonia were made at the end. The quinhydrone electrode was used for pH determinations. Nitrates were determined by the phenoldisulphonic acid method. The ammonia was collected in 300 c. c. Florence flasks after consecutive leachings with 100, 50, and 50 c. c. portions of normal KCl and 50 c. c. water. The ammonia was distilled over after neutralizing with magnesium oxide.

TABLE XI

EVOLUTION OF CARBON DIOXIDE FROM CANE TRASH ADDED TO PUERTO RICO SOILS WITH OR WITHOUT THE ADDITION OF MINERALS

Treatments	After 28 days			
	Total mgm. C as CO_2	pH	Nitrate mgm. of nitrogen in flask	Ammonia mgm. of nitrogen in flask
Trash	124	7.1	None	None
Trash + $(NH_4)_2HPO_4$ + K_2HPO_4	445	6.6	None	16.0
Trash + $NaNO_3$ + K_2HPO_4	330	9.0	15.3	None
Múcara clay	37	6.8	9.2	1.8
Múcara clay + trash	351	6.7	None	None
Múcara clay + trash + $(NH_4)_2HPO_4$ + K_2HPO_4	441	7.0	1.8	17.7
Múcara clay + trash + $NaNO_3$ + K_2HPO_4	452	7.2	12.5	None.
Río Piedras clay	27	6.7	5.7	7.4
Río Piedras clay + trash	303	6.4	None	None
Río Piedras clay + trash + $(NH_4)_2HPO_4$ + K_2HPO_4	267	6.6	None	28.6
Río Piedras clay + trash + $NaNO_3$ + K_2HPO_4	292	7.4	None	11.6
Bayamón clay loam	27	5.0	2.4	4.0
Bayamón clay + trash	225	5.0	None	None
Bayamón clay + trash + $(NH_4)_2HPO_4$ + K_2HPO_4	260	5.5	None	32.0
Bayamón clay + trash + $NaNO_3$ + K_2HPO_4	317	5.3	20.1	None

INFLUENCE OF SOIL TREATMENT UPON THE MICROBIAL POPULATION

In the previous treatment given to the Puerto Rico soils the number of fungi, bacteria and actinomyces were determined after fifteen and thirty days by the plate method. Peptone-Glucose acid Agar (**21**) was the medium used for fungi. Sodium Albuminate Agar (**22**) was the medium used for bacteria and actinomyces. Five plates were poured for each treatment. The plates were incubated at 28° C. Fungi were counted after three days. Bacteria and actinomyces were counted after ten days in the same plate.

TABLE XII

ABUNDANCE OF MICROORGANISMS IN SOILS KEPT AT OPTIMUM MOISTURE

Treatment	Number of Fungi X 1,000							
	Río Piedras Clay		Bayamón Clay Loam		Múcara Clay		Toa Silt Loam	
	15 days	30 days	15 days	30 days	15 days	30 days	15 days	30 days
Soil alone	27.0	29.0	134.0	40	46	28	40	42
Soil + $CaCO_3$	70	28	36	39	31	22	28	35
Soil + dried blood	433	220	447	346	216	236	290	496
Soil + $(NH_4)_2SO_4$	50	28	70	139	45	26	43	58
Soil + $(NH_4)_2SO_4$ + $CaCO^3$	57	15	90	62	40	24	25	11
Soil + cane trash	700	103	697	856	236	180	206	286
Soil + cane trash + $(NH_4)_2HPO_4$	933	230	837	836	560	166	510	454

Treatment	Number of Bacteria X 100,000							
	Río Piedras Clay		Bayamón Clay Loam		Múcara Clay		Toa Silt Loam	
	15 days	30 days	15 days	30 days	15 days	30 days	15 days	30 days
Soil alone	63	170	227	69	34	83	69	351
Soil + $CaCO_3$	180	261	134	89	80	146	75	281
Soil + dried blood	163	354	1,130	250	24	334	128	864
Soil + $(NH_4)_2SO_4$	91	208	140	82	51	54	61	672
Soil + $(NH_4)_2SO_4$ + $CaCO_3$	180	58	158	93	42	84	99	530
Soil + cane trash	490	222	1,246	640	280	100	96	468
Soil + cane trash + $(NH_4)_2HPO_4$	700	236	1,695	235	264	448	174	748

Treatment	Number of Actinomyces X 100,000							
	Río Piedras Clay		Bayamón Clay Loam		Múcara Clay		Toa Silt Loam	
	15 days	30 days	15 days	30 days	15 days	30 days	15 days	30 days
Soil alone	29	40	48	20	8	46	17	32
Soil + $CaCO_3$	61	52	14	13	26	29	23	26
Soil + dried blood	360	154	110	150	224	206	220	306
Soil + $(NH_4)_2SO_4$	46	62	6	8	34	42	29	47
Soil + $(NH_4)_2SO_4$ + $CaCO_3$	68	24	14	27	16	17	27	33
Soil + cane trash	267	88	47	100	100	20	60	96
Soil + cane trash + $(NH_4)_2HPO_4$	363	144	210	85	116	152	116	112

DISCUSSION OF RESULTS

The two samples of trash differ considerably in composition, as shown in Table I. This may be due to differences in the varieties, to age effects or to the methods of sampling the materials. S.C. 12-4 trash was taken as dead leaves from the lower part of the stems. P.O.J. 2714 trash was gathered from soil surface around the cane. Waksman and Tenney (**26**) have shown that the composition of plant remains is different with different plants and the same plant at different stages of growth. The younger the plant and the less mature it is the greater will be the content of readily decomposable material.

The S.C. 12–4 has 2.81 per cent less water soluble organic matter, 1 per cent more hemicelluloses, 3.14 per cent more cellulose, 4.53 per cent more lignin and 6.49 per cent less ash than the P.O.J. 2714. The furfural determination shows that almost all the hemicelluloses of the P.O.J. 2714 were pentosans.

If both samples of trash were placed under similar environmental conditions, it would seem likely that the composition of the variety P.O.J. 2714 would be such as to result in its more rapid decomposition.

Celluloses and hemicelluloses add 55.24 per cent for P.O.J. 2714 and 59.17 per cent for S.C. 12(4). It is very important, therefore, to understand the role of soil microorganisms in decomposing such complexes for energy purposes. Organisms capable of decomposing celluloses under aerobic conditions are found among various groups of fungi, among the actinomyces and among certain specific bacteria. However, under anaerobic conditions, the fungi and actinomyces do not thrive and bacteria alone are entirely concerned in the process. Many fungi are capable of decomposing hemicelluloses. Certain specific bacteria and lower animals are also capable of assimilating hemicelluloses.

Certain hemicelluloses are more readily decomposed than others. The degree of decomposition varies with the nature of the plant and the type of hemicelloluse. Pentosans are more readily decomposed than hexosans.

Table 2 gives the dry weight losses of sugar-cane trash composted for thirty and sixty days with or without additional inorganic nitrogen. The trash was inoculated with soil infusion to provide for the presence of the soil variable microflora and microfauna. No deduction was made for the dry weight increase due to the addition of $(NH_4)_2SO_4$ because of the complicated nature of the chemical changes affecting this salt during microbial activities.

In the compost material containing 88 per cent water, evil smelling substances, seemed to indicate that some anaerobic decomposition was going on. Such evil smelling substances were not noticed in the other treatments. The presence of 88 per cent moisture represents the addition of 733 per cent of water to the dry material. The degree of saturation seems to be too high for the free circulation of air. As conditions were partly anaerobic, it is advisable, not to compare the results obtained in the 88 per cent H_2O treatment with those obtained in the 66 and 80 per cent H_2O treatments whose average value in this discussion is taken to represent aerobic decom-

position. The nature of the processes involved would be different in both cases.

It is obvious, that the information obtained from losses of dry weight, is of a very limited value. The individual groups constituting the trash complex are not affected at the same rate. Some groups tend to increase; others tend to decrease and others tend to remain more or less constant. The increase in some of the groups compensates the decrease in others and therefore an appreciable change of the total dry material is not noticed.

The ether and alcohol soluble fractions constitute a heterogeneous group of complexes such as oils, waxes, resins, tannins, terpenes, alkaloids, etc. As the percentage of these two groups in sugar-cane trash is quite small, namely around 3 per cent, not much stress is to be laid on their fate during the processes of decomposition. It seems, however, that about 50 per cent of the ether soluble fraction is of such nature as to decompose during the first thirty days. The rest seems to be more resistant to decomposition; even with the addition of nitrogen.

The celluloses and hemicelluloses disappeared more rapidly than could be accounted for by the decrease in total dry weight. The decrease in weight due to their decomposition is balanced by the accumulation of proteins. Their disappearance may be due to actual loss of carbon as carbon dioxide or to transformation into the new complexes synthesized by the microorganisms. It must be remembered that in such a biological process as, composting sugar-cane trash, decomposition and synthesis take place side by side. The increase in water insoluble protein corroborates the synthesis of new protein cell material.

The lignin fraction remains more or less constant. Waksman and Tenney (**28**) studied the decomposition of composted rye straw under aerobic conditions for a period of 386 days. They found that the decomposition of celluloses and hemicelluloses accounted for most of the decomposed plant materials. This was accompanied by an increase of water insoluble protein and lignins.

Further studies on sugar-cane trash decomposition for a period over sixty days would give more evidence of the fate of the lignin fraction. It also will show up to what limit the celluloses and hemicelluloses become resistant to decomposition.

The addition of nitrogen in both, aerobic and partly anaerobic conditions, activated the heterotrophic organisms in decomposing more celluloses and hemicelluloses. This was accompanied by a

larger increase of water insoluble protein and water soluble organic matter.

The total ash content remained more or less constant in all the treatments to which nitrogen was not added. The increase in ash content due to the addition of one gram of $(NH_4)_2SO_4$ varied only from 0.06 to 0.25 gram. This supports the statement previously made:

"No deduction was made in Table 2 for the dry weight increase due to the addition of $(NH_4)_2SO_4$ because of the complicated nature of the chemical changes affecting this salt during microbial activities."

Tables IX and X show that with the progress of decomposition there was a decrease of the nitrogen soluble in cold water and a corresponding increase in the nitrogen hydrolizable by dilute hydrochloric acid and in the more resistant or so-called "humin" nitrogen. This points, once more, to the building up by microorganisms of proteins and other complex organic nitrogenous compounds.

The 212 milligrams of nitrogen added to the compost was in excess to that required by the active microorganisms. Under aerobic conditions, after thirty days, an average of 122 milligrams of nitrogen as ammonia was recovered. After sixty days, 106 milligrams were thus recovered. The ratio of available nitrogen used to hemicelluloses and celluloses decomposed was as follows:

	66 per cent water	80 per cent water	88 per cent water
30 days	1:39	1:28	1:38
60 days	1:28	1:39	1:22

Practically all the nitrogen was recovered in the residual material. This shows that there was no loss of nitrogen either by volatization or reduction processes. These results throw further light upon the problem of synthesis of new protein material as a result of the activities of the microorganisms which bring about the decomposition of the celluloses and hemicelluloses. In the absence of additional nitrogen, the increase in the amount of water insoluble protein took place at the expense of the water soluble simple nitrogenous compounds. Some of the nitrogenous substances synthesized by the microorganisms, are only slowly available sources of nitrogen for soil microorganisms, otherwise the celluloses and hemicelluloses would have undergone a much more rapid decomposition. The slight increase of the total nitrogen fraction in the compost to which no

nitrogen was added may be due to nitrogen fixation. Energy for the nitrogen fixers may have been taken from the disintegration products resulting from the decomposition of celluloses and hemicelluloses.

At the end of the experimental periods the trash to which nitrogen was added was more brittle and readily crumbled between the fingers. Probably such a material would not interfere with the plowing operation. The decomposed material resembled soil humus in color.

Further studies extended over longer periods of time on decomposition of cane trash in the presence of available minerals, especially nitrogen and phosphorus, should give information on how to use the minerals in the most economical way.

Carbon dioxide as an index of soil fertility has been discussed by Waksman and Starkey (**24**).

Results given in Table XI indicate that the Múcara clay liberated the greatest amount of carbon dioxide in all the treatments. The rapidity of trash decomposition depends on the rate by which soil microorganisms utilize available minerals present, especially nitrogen. It seems that the Múcara clay supplies minerals at a faster rate than the two other soils. The Bayamón clay loam seems to have the lowest mineral spuplying power. From field returns it can be said that the Múcara clay is a better sugar-cane soil.

Carbon dioxide evolution in the Río Piedras clay was not stimulated by the addition of minerals. Probably some physical factor must be responsible for repressing microbial activity. May be this soil, at optimum moisture conditions, would behave differently.

Microorganic activity was repressed when $NaNO_3$ was added to the trash in the absence of soil. Probably this was due to high alkalinity (pH 9.0) or to toxicity of the sodium or nitrate ion. The buffer effect of the soil seems to check such effect.

No definite explanation can be given for the reduction of nitrates to ammonia when $NaNO_3$ and trash were added to the Río Piedras clay. This might have been due to an involuntary addition of $(NH_4)_2HPO_4$ for $NaNO_3$; but the increase to (pH 7.4) seems to indicate that there was not such an error.

Fungi, bacteria and actimomyces were most abundant when dried blood and cane trash were added. The organic matter in the form of those materials offered a good energy source for the heterotrophic soil organisms which develop well in the plate method.

When straw is added to the soil, the microorganisms decomposing

celluloses and hemicelluloses use the available nitrogen present in the soil, up to a certain limit. It seems dangerous to leave trash on a nitrogen starving soil planted to cane. The ratio between the amount of cellulose decomposed and the amount of nitrogen assimilated is about 30:1 in the case of fungi and aerobic bacteria. However, in the soil, where the cells of microorganisms freshly synthesized are constantly decomposed by other organisms, the ratio is 50–60:1 (**25**). In other words; for every unit of nitrogen that can become available in the soil in a definite period of time, about 50 to 60 units of cellulose will be decomposed. Such a ratio has not been experimentally established for hemicelluloses; but it is believed that an identical ratio prevails.

To hasten the decomposition of sugar-cane trash in the sugar-cane fields it is evident that available nitrogen must be given to the soil microorganisms. Nitrogen is supplied with great cost to most crops and especially so, to sugar-cane. It is a standard practice in Hawaii, Java, and Puerto Rico to apply heavy applications of inorganic fertilizers to fields of sugar cane. Hawaii leads with applications of 600 to 1,000 pounds of a complete fertilizer per acre followed by 400 to 600 pounds of sodium nitrate or ammonium sulphate. Puerto Rico is approaching Hawaii and applies 400 to 800 pounds of a complete fertilizer followed by 300 to 400 pounds of ammonium sulphate. Java growers are strong supporters of ammonium sulphate alone. They apply from 100 to 1,200 pounds per acre. Cuba is also using large amounts of fertilizers.

In the tropics, especially in the regions of high rainfall, there are great losses of available nitrogen in the run-off and percolating waters. Sugar-cane trash would serve as a store of available nitrogen. The nitrogen deposited as proteins in the cells of soil microorganisms would not leach so readily. Further microbial activity would convert the stored nitrogen into forms available for the sugar-cane plant.

In 1927, Albrecht (**2**) reports:

> "Some recent work by the Oregon Experiment Station indicates that artificial manure can be made successfully with ten pounds of nitrogen per ton of straw. It is customary in England to add about fourteen parts of nitrogen per ton of straw."

The average nitrogen per acre added to the sugar-cane fields of Hawaii and Puerto Rico is about 180 and 148 pounds, respectively. The addition of a part of this nitrogen to the sugar-cane trash would hasten its decomposition in the soil. Such addition of nitrogen to

the trash would tend to improve the trash physical condition for the plowing operation.

A farmer in the United States adding every year an average of 2,000 pounds of organic matter per acre is doing quite well. Such an average for the tropics would be too low because the decomposition of organic matter is greatly hastened by optimum climatic conditions.

Considering that thirty tons of cane per acre gives about ten tons of green straw and assuming that the green straw contains about 75 per cent of water; 5,000 pounds of dry material would remain in the soil. Deducting for ash, 10 per cent of the dry weight; 4,500 pounds of organic matter will be left for enriching the soil supplies of organic matter.

Nitrogen could be supplied, as a means of hastening trash decomposition, by a quick growing leguminous plant. Nitrogen could also be supplied by scattering over the trash part of the fertilizer added to the sugar-cane plant. Perhaps, it would be practical to adopt a wet spraying method.

The economic advisability of applying a source of available minerals, especially nitrogen, as a means of hastening trash decomposition must be established by adequate experimentation. The questions to be answered are: What form of nitrogen is the most adequate? What amount of nitrogen must be added to make this practice a paying proposition? How should this nitrogen be added? How long will it take for the nitrogen transformed into the complex proteins of microbial protoplasm to become available for the use of the plant?

SUMMARY

The decomposition of sugar-cane trash on the basis of its chemical composition has been studied when kept at different moisture contents with or without the addition of inorganic nitrogen for a period of thirty and sixty days at 28°C. Results lead to the following conclusions:

(1) The addition of inorganic nitrogen to the composted trash hastened the decomposition processes.
(2) The ether and alcohol fractions account for a very slight portion of the total organic matter decomposition.
(3) The decomposition of the celluloses and hemicelluloses account for most of the decomposed organic matter. As such groups represent a good source of energy for the heterotrophic organisms their disappearance may be due to actual loss of carbon dioxide or to transformations

into the new complexes synthesized by the microorganisms. This synthesis is further proven by an accumulation in crude protein and an increase in the water soluble matter.

(4) The lignin and ash fractions remain more or less constant.

(5) Practically all the nitrogen present and added was recovered in the residual material. There was no loss, therefore, of nitrogen either by volatilization or reduction processes. The slight increase of the total nitrogen fraction in the compost to which no nitrogen was added may be due to nitrogen fixation. Energy for the nitrogen fixers may have been taken from the disintegration products resulting from the decomposition of celluloses and hemicelluloses.

(6) The addition of nitrogen improved the physical conditions of the trash. It was more brittle and readily crumbled between the fingers.

(7) Addition of trash to three soil types from Puerto Rico increased the rate of carbon dioxide seven to nine times.

(8) Influence of soil treatment upon the microbial population showed an increase in the numbers of fungi, bacteria and actinomyces when dried blood or sugar-cane trash was added to the soils.

ADDENDA

After this manuscript was sent to press the author received a reprint of Owen's and Denson's (31) recent work at Louisiana on "The effect of plowing under cane trash upon the available nitrogen of the soil." The investigation was outlined in the following heads:

1. "The various organic constituents of cane trash.
2. The rate of decomposition of cane trash and its various fractions as measured by the evolution of carbon dioxide.
3. The effect of age upon the depressing action of cane trash upon soil nitrates.
4. The influence of cane trash upon the soil microflora.
5. The utilization of forms of nitrogen other than nitrates for the decomposition of cane trash in soils.
6. The cycle of nitrogen incorporation and release from microbial protoplasm.
7. The influence of cane trash upon plant growth.
8. The effect of turned under cane trash upon moisture retention in the soil.
9. The agronomic phases of plowing under cane trash."

The authors conclusions were:

1. "The addition of fresh cane trash to soils containing nitrates causes a very rapid transformation of the nitrogen into organic forms.

2. The depressing effect of cane trash upon nitrates, diminishes at a fairly constant rate when this crop residue is in contact with the soil, and under ordinary conditions it has perhaps lost most of its pernicious effects at the time the fertilizer is applied to cane.
3. The addition of fresh trash retards appreciably the rate of growth of corn plants, but the incorporation of trash which has been partially buried for several months, increased the yields and the initial rate of growth.
4. The addition of cane trash to soils increase their water holding capacity, and decreases their rate of drying, so that in seasons of drought this may be quite a factor in conserving the moisture of the soil.
5. The addition of cane trash to soils results in appreciable gains of total nitrogen, indicating the stimulation of the nitrogen fixing bacteria by the products resulting from the decomposition of organic matter incorporated in the soil.
6. The fact that field experiments over a period of several years at this Station, have shown no decrease in crop yields from the practice of turning under cane trash it would appear that the nitrate nitrogen immobilized by the presence of the organic matter, is in excess of the immediate requirements of the growing crop. This would make the practice of turning under trash, consistent with the necessity of conserving the surplus available nitrogen in the soil.
7. Whether the continued practice of incorporating such large quantities of organic matter with a C:N ratio of approximately 1:40 would tend to so increase the accumulation of the more resistant constituent lignin, as to unfavorably affect the composition, and the productiveness of a soil is a question, the importance of which warrants further study."

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A BIBLIOGRAPHY OF THE BANANA ROOT-WEEVIL

By Mortimer D. Leonard

The banana root-weevil, *Cosmopolites sordidus* Germar, is widely distributed thruout the Tropics, its distribution apparently being coincident with that of its only host plants—all species and varieties of bananas and plantains, Musa spp. Altho it is not a serious pest thruout its whole range the insect is always of sufficient importance so that its presence is viewed with alarm, for bananas and plantains are a staple food with the natives wherever they are grown and of course are a large export crop in some countries.

The literature dealing with the banana root-weevil is widely scattered in the agricultural journals and annual reports and bulletins of the departments of agriculture and agricultural experiment stations of the tropical countries of the world. To compile the present bibliography has, therefore, been no small task. Its publication is believed worth while since many of the papers included are not readily obtainable by most of the workers in tropical countries with limited library facilities.

An attempt has been made to list every reference it was possible to find in which this insect was mentioned. The relative value of each article is indicated by an annotation following the reference. A total of 215 titles is given, of which the writer has been able to personally examine all but 23; these latter are marked with an asterisk. In some cases the original publication was not seen but careful typewritten copies were received thru the courtesy of Prof. C. R. Crosby of Cornell University, Miss Mabel Colcord, Librarian of the United States Bureau of Entomology, and the Librarian of the United States Department of Agriculture. Acknowledgments are made to the above for this very necessary assistance as well as to the librarians of Cornell University and to Mr. A. J. Mutchler of the American Museum of Natural History for much help in looking up references.

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Borer increasing in St. Catherine; banana clean-up order suspended because of undue hardship its full enforcement would entail.

* 1916. Proclamation concerning the black weevil borer of bananas. Jamaica Gaz. Extraordinary, 28th. April.

"Orders destruction by fire or otherwise of banana and plantain plants or parts of plants infected by the black weevil borer (*Cosmopolites sordidus*). No suckers may be planted on or removed from land found to be infested with this weevil." (Rev. Appl. Ent. 4: 320, 1916.)

* 1916. Dealing with the banana borer in Jamaica. Daily Gleaner, Kingston, Jamaica, 21st. March, pp. 13–14.

Report of special committee on banana borer of Jamaica Agr. Soc. Recommends destruction of infested suckers, planting infested land with cane or bush for a few years and planting or encouragement of bush between slightly infested or clean land. (Rev. Appl. Ent. 4: 255, 1916.)

* 1916. Black borer beetle which is attacking banana trees. Daily Gleaner, Kingston, Jamaica, 22nd. April, p. 6.

"An investigation is being made as to the areas in Jamaica on which *Cosmopolites sordidus* occurs that these districts may be declared infested and an order issued making this insect a notifiable one. It is proposed to introduce from Fiji the Histerid beetle, *Plaesius javanus* Er., which is predaceous on this weevil." (Rev. Appl. Ent. 4: 256, 1916.)

1916. Banana boring weevil, a new pest in bananas. Jour. Jamaica Agr. Soc. **20**: 103.

Brief reference to a former notice.

1916. The black borer weevil of banana. Jour. Jamaica Agr. Soc. **20**: 145–146.

Refers briefly to appointment of a committee of the Board of Managers of Agr. Soc. to recommend procedure

to Government. Suggested declare it pest or notifiable pest. Besides St. Andrews found in St. Catherine, but not bad.

* 1917. Banana borer. Jour. Jamaica Agr. Soc. **21** (5): 169–173.

Extensive memorandum of Commissioner of Agriculture for the West Indies, Sir. Francis Watts; believes can be prevented from becoming serious by careful cultivation; trapping and selection of only healthy corms suggested. (Rev. Appl. Ent. 5: 435, 1917.)

1917. Banana borers. Banana beetle trap. Jour. Jamaica Agr. Soc. **21**: 230–231.

Brief; recommends clean cultivation and vigorous plants; young plants worst infested. Trap of ½ bulb kept fresh caught many beetles in one section.

* 1918. Agricultural Experiments. Jamaica Dept. Agr. Ann. Rept. for year ended 31st. March 1918, pp. 14–18.

Recommends submerging banana suckers in water for 48 hours; trapping the adults and keeping fowls on small plantings; carbon bisulfide kills the plants. (Rev. Appl. Ent. 7: 85, 1919.)

* 1918. Order relative to the black weevil borer of bananas. Jamaica Gaz. Extraordinary, 11th May.

Revokes proclamation ordering destruction of infested banana and plantain plants. (Rev. Appl. Ent. 6: 320, 1918.)

* 1918. Work connected with insect and fungus pests and their control. Rept. Agr. Dept. St. Lucia 1917–1918, pp. 5–15.

Report on trip made by Dr. J. C. Hutson to investigate habits of *C. sordidus;* nature of damage and importance described in detail; recommends good cultivation and several other obvious remedies. (Rev. Appl. Ent. 6: 514, 1918.)

1919. Disposiciones vigentes sobre el servicio de sanidad vegetal. Cuba, Sec. Sanidad Vegetal, Circ. 5, p. 23.

Leaves and shoots of bananas proceeding from Jamaica prohibited entry on account of *C. sordidus.*

1919. Banana Borer. Jour. Jamaica Agr. Soc. **23** (4): 137.

Brief; soak bulbs in water for 24 hours and trap, examining the traps every 3 or 4 days.

1921. Entomología. Bol. Asoc. Agr. Ecuador **1**(3), 2 pp.

Mentioned as having been found [by H. K. Plank].

1921. Work connected with insect and fungus pests and their control. Rept. Agr. Dept. St. Lucia, 1920, p. 3.

Brief; weevil borer chiefly responsible for patches of dying bananas in peasants' holdings thruout the island; recommends destroying infested plants and clean cultivation.

1922. Os insectos damninhos XXII—Uma coleobroca da bananeira, *Cosmopolites sordidus*. [Injurious insects XXIII—A Coleopterous banana borer, C. sordidus]. Chacaras e Quintaes **26**(3): 197–198, 5 figs.

Brief general account.

1922. Work connected with insect and fungous pests and their control. Rept. Agr. Dept., St. Vincent for 1921, p. 24.

"Caused a fair amount of damage on one plot of bananas."

1923. The banana borer (*Cosmopolites sordidus*). Agr. Circ. Dept. Agr. Fiji **3**(4): 59–60.

Briefly mentioned as widely distributed and destructive in in Fiji.

1923. Banana borer order, 1923. Jour. Jamaica Agr. Soc. **27**(11–12), p. 1022.

Must not leave banana or plantain neglected or uncultivated. Cut infested plants into ¾ inch thick pieces and scatter over soil.

1924. The banana and its cultivation, with special reference to the British Empire. Bull. Imp. Inst. **22**(3): 319–320.

Brief general account; recommends trapping, selection of uninfested bulbs for replanting and removal of old stumps of plants after harvest.

1924. Banana borer control. Agr. Circ. Dept. Agr. Fiji **5**(1): 75–76.

Placsius javanus, introduced 11 years previously, now well established.

1924. Report of the division of entomology, fiscal year 1923–24. Ann. Rept. Ins. Exp. Sta. Porto Rico for 1923–24, pp. 97–98.

Trapping at the Station planting, continued from August to June, showed great reduction in numbers of weevils collected but indicates necessity of continuous trapping if borer injury is to be reduced to a minimum.

1924. Work connected with insect and fungus pests and their control. Rept. Agr. Dept. St. Vincent for 1923, p. 29.

"Found in some few instances attacking banana plants."

1925. Banana beetle borer (*Cosmopolites sordidus*). Agr. Cir. Dept. Agr. Fiji **5**(2) : 88.

Brief note on injury and extension of regulations to several additional islands.

* 1925. Proclamations under the plant diseases act. Govt. Gaz. [New South Wales] No. 97.

Listed as a pest for purposes of the Act. (Rev. Appl. Ent. 13: 639, 1925.)

1925. Banana root-stock borer. Farming in S. Africa **1**(6) : 209.

Records first discovery of *C. sordidus* in South Africa in 1924 in Natal and quotes from Mc Carthy's account in Agr. Gaz. N. S. Wales (1920).

1927. Libya: decree of 13th. September 1926 on importation of plants. Internat. Rev. [Sci. & Pract.] Agr. N. S. **18**(3) : T187–T188.

Brief note; banana plants from every source prohibited importation on account of *C. sordidus.*

1927. Cuarentena exterior Num. 7. Bol. Mens. Defensa Agr. Sec. Agr. y Fomento, México **1**(7) : 536–537.

Note stating that importation of banana plants or parts from foreign countries is prohibited on account of *C. sordidus.*

* 1927. New South Wales: Plant Diseases Act. 1924. Regulations Nos. 27–31. Govt. Gaz. No. 168, reprint, 2 pp.

Banana plants restricted in movement and infested plants to be treated in several ways. (Rev. Appl. Ent. 16: 124, 1928.)

* 1928. New South Wales: Proclamation under the plant diseases act, 1924. Govt. Gaz. No. 128, reprint, 1 p.

Prohibits introduction of banana, plantain or manilla hemp plants or plant parts, except under permit on account of *C. sordidus.* (Rev. Appl. Ent. 17: 103 1929.)

1929. Report of the division of entomology, Ann. Rept. Ins. Exp. Sta. Dept. Agr. & Labor Porto Rico for 1927-1928 : 95.

Brief note.

1930. Division of Entomology. Rept. Comm. Agr. and Labor Porto Rico for fiscal year ended June 30, 1929, p. 700.

Note stating that studies have been made; damage is serious.

Ballou, H. A. 1912. Insect pests of the Lesser Antilles. Imper. Dept. Agr. West Indies, Pamphlet Ser. 71, p. 112.

Brief mention.

1916. The banana weevil. Agr. News [Barbados] **15** (364) : 123.

Brief account of general distribution, habits and spread; recommends destroying all infested stools and replanting only uninfested ones.

1922. Insect pests of plantains and bananas. West Ind. Bull. 19(2) : 267.

Listed as generally distributed and doing severe damage in St. Lucia, B. W. I.

1928. Control of insect pests. Rept. St. Lucia Agr. Dept. for 1927, p. 10.

Mentioned as causing bananas to be treated by the Banana Inspectors.

1929. Diseases and pests within the colony. Rept. St. Lucia Agr. Dept. for 1928, p. 14.

Mentioned as a pest in order to comply with requirements of the Plants Protection Ordinance.

1931. Banana borer. Jour. Jamaica Jour. Agr. Soc. **35**(2) : 63.

Still doing considerable damage in some centers while in others reasonably well controlled; urges covering crown of

growing plant with earth and also butts after cutting back to the crown; also systematic trapping and cleaning up débris and chopping up of stumps within one month after harvesting bananas.

Barrett, O. W. 1928. The Tropical Crops, pp. 182–183.

Brief statement of nature and extent of damage.

Benson, A. H. 1920. Remedies suggested [for the banana weevil.] Queensl. Agr. Jour. **13**(4) : 168.

Brief description of precautionary measures, destruction of beetle in infested plantations, and how to destroy infested plants.

Brugiroux, A. 1928. French Settlements in Oceania: some insects damaging crops. Internat. Rev. [Sci. & Pract] Agric. **19**(4) : 400.

C. sordidus listed as a pest in Tahiti.

Carment, A. G. 1922. Report on mycological work done by Dr. A. G. Carment, medical officer of health and bacteriology. Dept. Agr. Fiji. Ann. Rept. for the year 1921. Council Paper No. 56: 8.

Brief note.

Charmoy, D. d' E. (See d' Emmerez de Charmoy.)

Cedaña, S. M. 1922. The banana weevil. Philippine Agr. **10**: 367–376, 2 pl.

Good general account for the Philippines; experimental data on injury, life history and control; a serious pest also of abaca (*Musa textilis* Nee.); bibliography of 14 titles.

Chevrolat, A. 1880. Diagnoses de curculionides de la Martinique. Le Naturaliste 1: 198.

Original description of *Sphenophorus pygidialis* listed doubtfully as a synonym of *C. sordidus* by Fletiaux and Sallé who state that the single type specimen could not be found in the Chevrolat collection.

1885. Calandrides. Ann. Soc. Ent. France, Ser. 6, **5**: 289–290.

Cosmopolites described as new genus. *Calandra sordida* Germar given as type and said to occur in Brazil, Java, Ceylon, Malacca, Saigon, China, Reunión, etc.

Crosby, C. R. and **Matheson, R.** 1914. Catalogue of [in-jurious] insects. In Cyclopedia of Horticulture by L. H. Bailey, **2**: 1049.

Listed as injurious.

Dammerman, K. W. 1929. The Agricultural zoology of the Malay Archipelago. The animals injurious and beneficial to agriculture, horticulture, and forestry in the Malay Peninsula, the Dutch East Indies and the Philippines, p. 98.

Brief general account; no control; *Placsius javanus* and *Crysopilus ferruginosus* mentioned as predators. This English edition is a revised and enlarged one based on the work in Dutch of about the same title published in 1919 in Amsterdam

de Azevedo Marques, L. A. 1922. A praga de bananeira no Río de Janeiro. (Biología de *Cosmopolites sordidus* Germ.). Bol. Soc. Ent. Brazil, 1922(1,2,3): 24–32, 2 figs.

Good, rather brief account of life history and control; first recorded in Brazil in 1918. Egg period determined as 8 days, larval 22, and pupal as 10, and various control measures discussed, including use of carbon bisulfide.

1923. A praga de bananeira no Rio de Janeiro. (Biologia do *Cosmopolites sordidus* Germar). Bol. Minist. Agr. Ind. e Comm., **11**(5): 109–117, 2 pls. (Dec. 1922).

Stages, life-cycle (40 days) and habits described; various measures recommended, including carbon bisulfide.

d' Emmerez de Charmoy, D. 1928. Entomological division. Ann. Rept. Dept. Agr. Mauritius for 1927, p. 13 (Port Louis).

"Bananas were reported as in previous years to be severely attacked with the stem beetle, *Cosmopolites sordidus*. Instructions for coping with the pest were issued to those concerned.

d' Emmerez de Charmoy, D. and **Gebert, S.** 1921. Insect pests of various minor crops and fruit trees in Mauritius. Bull. Ent. Res. **12**(2): 190.

"Banana.—The black banana weevil, *C. sordidus* Germ. is the only pest. The larvae live in the root-stock and occur

sometimes in such great numbers as to cause the death of the plant. The varieties known as 'Gingeli' and 'Banana Carrée' are particularly affected.''

de Seabra, A. F. 1920. Études sus les maladies et les parasites du cacaoyer et d' autres plantes cultivées á S. Thomé. 22. Le *Cosmopolites sordidus* Germ., á S. Thomé. Lisbon, Companhia Agr. Ultramarina, pp. 3–7.

General account of in the Island of San Thomé; known as a pest since 1907.

1922. Études sur les maladies et les parasites du Cacaoyer et d' autres plantes cultivées a S. Thomé. No. 22. Le *Cosmopolites sordidus* Germ. a S. Thomé. Mém. publ. par Soc. Portugaise Sci. Nat., Sér. Zool. No. 2, fasc. **2**: 101–104, 3 figs.

Brief account of nature of damage, detailed description (with figures) of the adult, with a note on several color variations; states it was recorded by Gravier in S. Thomé in 1906.

* 1922. Insects de S. Thomé provenant de la mission d' étude du Professeur Sousa da Camara en 1920.—Separate from Anais do Instituto de Agronomia, 21 pp., Coimbra, Portugal.

Recorded as attacking banana. (Rev. Appl. Ent. 11: 308, 1923.)

Dejean, P. F. M. A. 1837. Catalogue des coleoptéres, 3rd. ed. p. 329.

Calandra striata Petit listed from Brazil; is also listed in 2nd Ed. p. 304 but I have not seen a copy of this edition.

Despeissis, A. 1924. Dept. Agr. Fiji Ann. Rept. for the year 1923. Council Paper 53: 3–4.

P. javanus has become established over an extensive area on the Rewa River and its tributaries; sanitation recommended.

Drieberg, C. 1916. Ceylon Agricultural Society; progress report 49. Trop. Agr. (Peradeniya) **46**(3): 191.

Note recording a plantain shoot received from Uda Alu deniya as infested.

* **Dupont, P. R.** 1915. Insect notes of curator, Botanic Station, Sychelles, 18th. March.

A consignment of Gros Michel banana suckers imported from Fiji were infested. (Rev. Appl. Ent. 3: 410, 1915.)

* 1918. Insect Notes. Curator's Report on Botanic Station, Seychelles, for 1917. (MS from Colonial Office, received by R. A. E. 24th. June, 1918.)

Reported that bananas were badly infested. (Rev. Appl. Ent. 6: 377, 1918.)

Edwards, W. H. 1925. Le charançon du bananier, *Cosmopolitis sordidus* Germ. Rev. Agr. de l' île Maurice, No. 22: 513–514.

Most important banana pest in Mauritius; length of stages given; best control is— burn all suspected plants, plant only healthy corms and use bait traps of pieces of corms.

Fahraeus, O. J. in C. J. Schoenherr's (1845) Genera et species curculionidum, cum synonymia hujus familiae, **8**(2): 251–252.

Original description of *Sphenophorus striatus* from Brazil.

Fawcett, W. 1913. The banana, its cultivation, distribution and commercial uses. (London), pp. 99–101.

Brief general account.

Fernández García, R. 1930. [Informe del] Estación Experimental Insular. Sección de Entomología. Inf. An. Com. Agr. y Trab. año fiscal 1929–1930: 181.

Brief note on beneficial results obtained by "cleaning" infected suckers with a knife; reduction of weevils by trapping and suggestion that attempt be made to introduce the predators, *Plaesius javanus* Er. and *Chrysopilus ferruginosus* Weid.

Fletcher, T. B. 1914. Some South Indian Insects, pp. 342-343, 1 fig.

Brief account; recorded from Malabar, Coimbatore, Godavari and Ganjam; usually a minor pest of plantain but occasionally doing considerable damage; destroy old stumps and use only uninfested suckers.

1917. Rept. Proc. Second Ent. Meeting held at Pusa, pp. 238–239.

Brief notes on distribution (thruout S. India and in W.

India as far north as Poona); destroy old infested stumps and select only non-infested suckers.

1920. An annotated list of Indian crop pests. Proc. Third Ent. Meet., Pusa **1**: 208.

Briefly recorded as a pest in certain parts of India and Ceylon.

* **Fletiaux, E.** 1903. Les Insects. Agr. Prat. Pays Chauds 2(10): 495–502; (12): 745–760.

Fletiaux, E. and **Sallé, A.** 1889. Coleoptéres de la Guadeloupe. Ann. Soc. Ent. France, Sér. 6 Vol 9: 455.

Listed as having been found in several localities in the island and as being common in rotten bananas. Four synonyms given—*striatus* Fahrs, *crenatus* Sturm., *javanus* Westerman in litt.) and doubtfully, *pygidialis* Chev.

Freeman, W. G. 1924. Plant Pathology. Rept. Dept. Agr. Trinidad and Tobago, for year ended Dec. 21st. 1924, p. 24.

"Continued to be a pest in all districts and during the year was recorded for the first time from Tobago."

Froggatt, W. W. 1919. The black banana stem weevil (*Cosmopolites sordidus* Germ.) Agr. Gaz. New South Wales **30**(11): 815–818, 6 figs.

Apparently first or at least one of earliest records of pest in New South Wales. Brief account of distribution, life-history and stages; excellent figures.

Froggatt, J. L. 1921. Banana beetle borer investigations (First Progress Report). Queensl. Agr. Jour. **16**(3): 200–208, 4 pls.

Report on the first half year's investigations on habits and life-history of the insect; control brief.

1922. The banana beetle borer, *Comopolites sordidus* Chev. (Curculionidae). (Second Progress Report.) Queensl. Agr. Jour. **17**(1): 39–45, 2 figs.

Brief description of life-history, habits and stages; detailed life-history data.

1922. Banana beetle borer. Queensl. Agr. Jour. **17**(5): 240–242, 2 figs.

A brief resumé of information obtained to date on injury, life-history and control.

1922. The banana beetle borer. Queensl. Agr. Jour. **18** (1) : 48–49.

Information on nature of injury, life-history and control, mostly quoted from previous reports.

1922. The banana beetle borer III. Queensl. Agr. Jour. **18**(4) : 279–288, 3 pls.

Life-history, injury and experiments of tests of chemicals to kill beetles with baits of corms; control measures outlined.

1923. The banana beetle borer. IV. Queensl. Agr. Jour. **19**(2) : 68–75, 3 pls., 6 tables.

Detailed life-history and control experiments: 96 hours in water 90 per cent beetles still alive and remained so for 10 days. P. D. B. (Paradiclorbenzene) kills in confined space.

1923. The banana beetle borer. V. Queensl. Agr. Jour. **19**(6) : 523, 5 pls.

Good account—life history and control experiments. Paris green best on sliced corms; after feeding 18–48 hours 99.4 per cent beetles died; sodium arsenite powder killed 92.5 per cent in 18–54 hours.

1924. The banana weevil borer. Queensl. Agr. Jour. **21**(4) : 275–276.

Brief report of three years' investigations to-date on life-history and habits.

1924. Banana weevil (*Cosmopolites sordidus* Chev.). Queensl. Agr. Jour. **21**(5) : 369–378, 2 pls.

Sixth progress report; beetles went 121 days without food; detailed account of experiments to date.

1924. Banana weevil borer. Queensl. Agr. Jour. **22**(3) : 154–156.

Brief summary of previous observations and experiments with detailed control recommendations based thereon; stated that liberation of *Plaesius javanus*, the predatory Histerid beetle from Java, is being continued on a small area near Brisbane and several adults found 2–3 months after liberation.

1925. The banana weevil borer (*Cosmopolites sordidus* Chev.). Queensl. Agr. Jour. **24**(6) : 558–593, pls. 140–148.

One of the best full accounts of this insect.

1926. The Banana Weevil Borer. Queensl. Dept. Agr. and Stock Div. Ent. and Plant Path. Bul. 4(N.S.) 40 pp., 9 pls.

Excellent full account for Queensland.

1928. Notes on banana insect pests. Queensl. Dept. Agr. and Stock, pp. 1–2.

Brief statement of nature of damage, varieties infested and general world distribution.

1928. Baiting for banana weevil control. Queensl. Dept. Agr. and Stock, 2 pp.

Materials and method described.

1928. Baiting for banana weevil borer control. Queensl. Agr. Jour. **29**(4) : 282–283.

Detailed description of how to make and use bait traps for catching adults.

1928. The banana weevil borer in Java with notes on other crop pests. Queensl. Agr. Jour. **30**: 530–541, 1 pl.

Same as Div. Ent. and Plant Path. publication which follows.

1928. The banana weevil borer in Java with notes on other crop pests. Div. Ent. and Plant Path., Dept. Agr. and Stock, Queensland, 12 pp., 1 pl.

Economic status in Java with notes and descriptions of the predators—*Chrysopila ferruginosa* Weid. and *Plaesius javanus* Er.—and their introduction into Queensland.

Germar, E. F. 1824. Coleopterorum novae aut minus cognitae descriptionibus illustratae, 1, (Coleoptera) p. 299, 2 pl. (Halae).

Original description as *Calandra sordida;* habitat given as the East Indies ("India orientali").

Ghesquiére, J. 1924. La maladie des bananiers dans le Bas-Congo. Bul. Agr. Congo Belge **15**(1): 171–172.

C. sordidus continuing to spread; first found near Zobe about 1913–14 and now found from the extreme west of Mayumbe to near Kisantu.

1925. La maladie du bananier au Congo Belge. (Notes complémentaires.) Bul. Agr. Congo Belge **16**(3–4): 556–560.

Brief general account.

1927. La maladie du bananier au Congo Belge. Rev. Zool. Bot. Afr. Suppl. 15 (Bull. Cercle Zool. Congolais **4**(1): [59]–[68], 1 fig.

Good account of insect and control in Belgian Congo. 17 references.

González Ríos, P. 1922. El gorgojo del banano. Rev. Agr. Puerto Rico **9**(6): 39–42, 3 figs.

Brief general account for farmers in the Island, describing recent discovery and giving life-history, nature of injury and suggesting urgent need for prevention of spread.

1930. Cultivo del banano en Puerto Rico. Est. Exp. Ins. P. R. Bol. 36: 49–51, 2 figs.

Brief general account for Porto Rico.

Goodman, W. S. 1929. Report of the Plant Breeder. Ann. Rept. Jamaica Dept. Agr. for Year Ended 31st. Dec. 1928, p. 13.

Brief; trapping has given good results.

Gowdey, C. C. 1920. Report of the government entomologist for 1918–1919. Uganda Dept. Agr. Ann. Rept. for year ended 31st. March 1919, p. 39.

Occurs not only on mainland but also on Bukassa Island, Sesse Group, which has been uninhabited for years; always worse on old uncultivated plots; recommends good cultivation and sanitation and rearing of the predaceous Histerid beetles.

1921. Annual report of the government entomologist. Ann. Rept. Jamaica Dept. Agr., for 1920: 25–27.

Brief note—favored by: poor soil, cultivation, land on bananas for long period, failure to destroy old bulbs and

excessive mulching; recommends cultivation, rotation and systematic trapping.

1922. [Annual report of the] Government entomologist. Ann. Rept. Jamaica Dept. Agr. 1921: 40.

Briefly notes several attacks which were investigated; due to planting infested suckers but in one planting control measures greatly lessened trouble.

1922. The banana borer, (*Cosmopolites sordidus* Germar). Jamaica Dept. Agr. Ent. Circ. 8, 8 pp., 2 pls.

General account; original life-history data with control; bibliography of six titles; the Histerid beetle predator, *Placsius javanus*, not very successful.

1923. The principal agricultural pests of Jamaica. Dept. Agr. Jamaica Ent. Bul. 2: 24–27, 2 pls.

Full account with control measures.

1923. Report of government entomologist, Ann. Rept. Jamaica Dept. Agr. 1922: 23.

Brief account; increasing in certain districts, but trap method satisfactory wherever systematically carried out.

1924. Report of the government entomologist. Ann. Report. Dept. Agr. Jamaica, 1923: 20.

Brief; very prevalent—a dry year; paris green and sodium arsenite on corms gave 80–90 per cent kill of weevils in 24 hours; suckers in water for 24 hours killed a certain number of all stages.

1925. Report of the government entomologist. Ann. Rept. Jamaica Dept. Sci. and Agr. for year ended 31st. Dec. 1924, pp. 17–18.

Three new localities infested, but situation in general greatly improved due to trapping and destruction of old bulbs.

1926. Report of the government entomologist. Ann. Rept. Jamaica Dept. Agr. for year ended 31st. Dec. 1925, p. 10, 11.

Control improving and no new localities infested; mention of experiments being conducted with paradichlorobenzene.

1927. Report of the government entomologist. Ann. Report. Jamaica Dept. Agr. for year ended 31st. Dec. 1926, p. 16.

Reported from two new localities; experiments with paradichlorobenzene reported to appear somewhat promising.

1928. Report of the government entomologist. Ann. Rept. Jamaica Dept. Agr. for year ended 31st. Dec. 1927, p. 20.

One new locality infested; experiments with a crude paradichlorobenzene continued and on one property 75 to 85 per cent effectiveness was obtained.

Gravier, Ch. 1907. Sur un coléoptore (*Spenophorous striatus* Fahr.) qui attaque les bananiers a San-Thomé (Golfe de Guinée). Bul. Mus. Nat. d' Hist. Nat., Paris, 13: 30–32.

Brief account of the banana root weevil (as *Sphenophorus striatus* Fahr.) in San Thomé where he states it is considerable of a pest; nature of injury briefly described and the account by Acacio Magro abstracted, who recommends chiefly immersion [of infested plants or bulbs ?] in Bordeaux mixture.

Gyllenhal, L. 1838 in Schoenherr's Genera et species curculionidum **4**(2): 925–926.

Technical description; habitat given as Java; from collection ("A. Dom.") Schuppel and Westermann.

Hadden, F. C. 1928. Some injurious insects of Formosa. Jour. Pan–Pacif. Res. Inst. **3**(1): 14.

"Bananas are attacked by *C. sordidus*, a recently accidentally introduced root and stalk beetle borer".

Hancock, G. L. R. 1926. Annual report of the assistant entomologist. Ann. Rept. Dept. Agr. Uganda, 1925, p. 28.

Listed as injurious.

Hargreaves, H. 1922. Annual report of the government entomologist, 1921. Uganda Dept. Agr. Ann. Rept., 1921: 62.

"No serious outbreak of this pest has been noticed. Larvae and pupae found on dying stems from which fruit had been cut."

1924. Ann. Rept. of the government entomologist. Uganda Ann. Rept. Dept. Agr. 1923, p. 19.

"Reported to be present in large numbers on two areas. Cutting out and destruction of infested stocks and the collection of adult weevils by means of trap stocks was recommended."

1925. Annual report of the government entomologist. Uganda Ann. Rept. Dept. Agr. 1924, p. 25.

Forty per cent of plantain trees in a garden infested.

1926. Report on the entomological section. Ann. Rept. Lands & Forests Dept. Sierra Leone for 1925, p. 16.

Listed as attacking bananas.

1928. Annual report of the government entomologist. Rept. Dept. Agr. Uganda, 1927, 11 pp. typescript.

Brief statement that a widespread outbreak of *C. sordidus* occurred on plantain and banana but the natives did little or nothing to control the pest.

(?) **Harris, W.** 1916. Report of the superintendent of public gardens. Suppl. to Jamaica Gaz. **39**(7): 118.

"Found to be attacking a small area of banana on the hillside west of the gardens but none of the plants in the gardens were attacked. It was decided however to destroy all plants on the garden lands."

Hopkins, G. H. E. 1927. Pests of economic plants in Samoa and other island groups. Bul. Ent. Res. **18**(1): 28.

"Swezey found this species attacking bananas and suggested that it was then recently established. It is still by no means common and does little damage."

Howard, L. O. 1930. A history of applied entomology (Somewhat annecdotal). Smithsonian Miscl. Coll. Vol. 84 (whole volume) Publ. 3065, pp. 413, 513, 523.

Brief mention of introduction of the Histerid beetle, *Plaesius javanus* into Fiji and later into Queensland, in both as predators of the banana root-weevil.

Hutson, J. C. 1921. Report of the division of entomology, April–June, 1921. Trop. Agr. [Ceylon] **57**(3): 194.

"Found to be prevalent [in the plantain districts] especially in plantations which are allowed to run more than two years without replanting. The work is being carried on."

1922. Report of the entomologist. Ceylon Dept. Agr. Rept., 1921: C. 23–26.

Brief: stated as prevalent in two areas injuring plantains; usually worse where no planting has been done for several years.

Jardine, N. K. 1924. Plantain root beetle borer. Dept. Agr. Ceylon, Leaflet 29, 1 p. 1 pl.

Brief account of life-history and control.

(?)1924. Plantain root beetle borer (*Cosmopolites sordidus* Germar). Yearbk. Dept. Agr. Ceylon, 1924, pp. 55–58.

Brief general account, mostly compiled from literature; trapping recommended.

* **Jepson, F. P.** 1911. Report on economic entomology. Fiji Dept. Agr. Council Paper 25, 89 pp., 7 pls.

1914. A mission to Java in quest of natural enemies for a coleopterous pest of bananas (*Cosmopolites sordidus* Chev.). Dept. Agr. Fiji Bul. 7, 18 pp., 3 pls.

General distribution; life-history in Fiji, habits and stages described of *Placsius javanus* Er., *Chrysopilus ferruginosus* Wied. and data on amount of *C. sordidus* larvae eaten by them; transportation of beetles to Fiji; five references cited.

1915. Division of entomology. Dept. Agr. Fiji. Ann. Rept. for 1914: 20.

Less abundant than in previous years, especially in districts in which the predaceous Histerid beetles from Java (*Placsius javanus*) had been established; data on status of *P. javanus* since introduction.

1916. Report on a visit to the Rewa River plantations. Dept. Agr. Fiji Pamphlet 25, p. 1.

Less prevalent than three years previously due to exceptionally wet season; conditions conducing to its spread are: poor drainage; neglect in planting only healthy suckers; failure to rotate often enuf; planting too close and leaving infested stems and stumps on ground.

1917. Division of entomology. Dept. Agr. Fiji Ann. Rept. for year 1916. Council Paper 107: 16.

Continued to be injurious to some plantings but apparently less so than formerly.

1919. Division of entomology. Fiji Dept. Agr. Ann. Rept. for the year 1918. Council Paper No. 32: 15.

Another importation of the predaceous beetle, *Plaesius javanus* from Java was received.

1924. Report of the acting entomologist. Ceylon Administ. Rept. Dept. Agr. 1923, p. D–20.

"The platain root borer (*Cosmopolites sordidus*) continues to cause considerable damage to plantains in the Rambukana and Matale Districts."

Jepson, F. P. and **Knowles, C. H.** 1920. Division of Entomology. Ann. Rept. Fiji Dept. Agr. for the year 1919. Council Paper No. 65. pp. 7–14.

Outline of proposed investigations.

Kermack, James. 1930. Fruit production for export.—Part II,—cultivation of the banana in Fiji. Agr. Jour. Dept. Agr. Fiji **3**(1): 36–37.

Recommends trapping weevils; *Plaesius javanus* is proving a successful predator.

Knowles, C. H. 1907. Agriculture (Report on, for the year 1906). Legislative Council Fiji. Council Paper No. 13, p. 7.

Appears to have been present for some time and becoming more common; destroy infested plants.

1909. Agriculture (Report on, for the year 1908) Legislative Council Fiji, Council paper 27, p. 20.

Injurious during the year; carbon bisulfide recommended.

1911. Agriculture (Report on, for the year 1910) Fiji. Council Paper No. 23, p. 5.

Mentioned.

1918. Division of entomology. Fiji Dept. Agr. Ann. Rept. for 1917. Council Paper No. 60: 8–9.

Prevalence and amount of damage; injury mostly on outer half of bulb; trapping and cultivation recommended; *P. javanus* introduced in 1913, not seen during 1917.

1919. Inspection of plantations. Fiji Dept. Agr. Ann. Rept. for the year 1918, Council Paper 32, p. 11.

Reported as much more plentiful during the year than formerly.

1919. Division of Entomology. Fiji Dept. Agr. Ann. Rept. for 1918, Suva, Council Paper 32: 13–14.

Serious damage during the year; generally distributed throughout the Colony; experiments shows that traps are effective but must be destroyed every 21 days; old infested plantations should be ploughed out; *Placsius javanus* in two consignments reintroduced during year.

1920. Agricultural work of the department. Fiji Dept. Agr. Ann. Rept. for the year 1919. Council Paper No. 65, pp. 5, 13.

Note on trapping beetles; beetle shows preference for West Indian plantains; is of the opinion that poor condition of plants in certain areas due to weevil.

1921. Entomological. Fiji Dept. Agr. Ann. Rept. for the year 1920. Council Paper No. 38, p. 8.

Continued injurious; *Placsius javanus* slow in increasing.

* **Knowles, C. H.** and **Jepson, F. P.** 1912. The banana in Fiji. Dept. Agr. Fiji Bul. 4, 17 pp., 3 pls.

Lawson, D. O. K. 1917. The striped cane weevil. Jour. Jamaica Agr. Soc. **21**(6): 219–220.

C. sordidus mentioned in connection with brief discussion of control of striped cane weevil.

Leng, C. W. and **Mutchler, A. J.** 1914. A preliminary list of the Coleoptera of the West Indies as recorded to January 1, 1914. Bul. Am. Mus. Nat. Hist. 33, Art. 30: 478.

Listed from Guadalupe.

1917. Supplement to preliminary list of the Coleoptera of the West Indies. Bul. Am. Mus. Nat. Hist. 37, Art. 5: 218.

Listed from Dominica.

Leonard, M. D. 1931. Entomology in Puerto Rico during the past decade. Jour. Econ. Ent. **24**(1): 146.

Brief note on status in the island.

López Domínguez, F. A. 1927. Informe anual del director de la estación experimental Insular de Puerto Rico, año fiscal 1925–26, p. 48.

Brief; has continued to spread as far as Utuado; Austra-

lian method of dusting the corms with Paris green and flour will be tried next year.

Mackie, D. B. 1917. A summary of the work of the pest control section for the year 1916. Philippine Agr. Rev. **10**(2) : 137–138.

Brief reference to death of a large number of abaca plants in Paete, Laguna.

1918. Some pests we do not want, why we do not want them, and how they may arrive. II. The banana root borer. Calif. State Comm. Hort. Bul. **7**(8) : 498–502 3 figs.

Refers to Federal quarantine 31 prohibiting entry of banana plants for propagation; general distribution, habits and injury described; especially in Philippines, grubbing out and burning infested plants recommended.

* **Magro, Acacio.** 1906. O musaphago ou bicho que ataca a bananeira pão; meies practicos de o destruir, San Thomé, 1906.

Mayné, R. 1916. Rapport sur une maladie des bananiers au Mayumbe (Bas-Congo). [Report on a banana plant disease at Mayumbe (Lower Congo)]. Bull. Agr. Congo Belge **7**(3–4) : 236–239.

Brief general account of the insect in Mayumbe.

McCarthy, T. 1920. Banana root borer, (*Cosmopolites sordidus* Germar). Agr. Gaz. New South Wales **31**(12) : 865–872, 2 pls., 1 fig.

Good general account but no experimental data included

McCreadie, J. 1922. Nasinu Experimental Station. Overseer's Report. Ann. Rept. Fiji Dept. Agr. for the year 1921. Council Paper No. 56, p. 5.

Plants poor owing to attacks of beetle; large numbers of beetles caught by trapping.

Misra, C. S. 1920. Index to Indian fruit pests. Proc. Third. Ent. Meet. at Pusa **2** : 593.

Listed as injurious to plantain.

Moreira, Carlos. 1922. Broca da bananeira. Chacaras e Quintaes **25**(3): 233–234.

Brief note regarding injury.

Moznette, G. F. 1920. Banana root borer. Jour. Agr. Res. **19**: 39–46, fig. 1, pls. 8–11.

Good account of the insect in Florida based on experimental data; detailed description of the stages of the insect; destruction of infested plants and use of bait traps recommended.

Muir, F. 1907. Notes on the sugar-cane hoppers and borers in the Malay States and Java. Rept. work Expt. Sta. Hawaiian Sugar Planters' Assn. Div. Ent. Circ. 2, pp. 8–9.

Mentioned as being fairly common in banana stems; stated that a large black Histerid beetle and its larva as well as the larvae of certain Hydrophilids feed on larvae of *C. sordidus.*

1908. Entomological Work in Borneo. Rept. work Exp. Sta. Hawaiian Sugar Planters' Assn. Div. Ent. Circ 4, p. 5.

Mentioned as being found (in company with *Sphenophorus ferrugineus*) in banana and palm trees, attended by Hydrophilid and Histerid beetle predators as in Java.

Muir, F. and **Swezey, O. H.** 1916. The cane-borer beetle in Hawaii and its control by natural enemies. Rept. Haw. Sugar Planters' Assn. Expt. Sta. Ent. Bul. 13: 15, 16 (and pp. 58, 61, 67).

(P. 15) Note on *Placsius javanus* being found as predaceous on *C. sordidus* and sent from Java to Honolulu; (p. 16) note stating that *Chrysopila* sp. larvae were numerous in sago palms and banana trees feeding upon beetle and dipterous larvae; Jepson's observations on both predators referred to. Pages 58, 61 and 67 are contained in reprints of Ent. Circulars 2 and 4 (See Muir 1907 and 1908).

Murray, P. W. 1918. Agricultural experiments. Suppl. to Jamaica Gaz. **41**(9): 182–184.

General account of distribution, habits, injury and control in Jamaica; burning difficult; carbon bisulfide not practical on plants buried under soil; soaking suckers 48 hours in water effective; good cultivation and clean management all necessary for effective control.

Newell, W. 1919. Report of the plant commissioner for the biennium ending April 30th., 1918, and Supplemental Reports. Quart. Bul. Fla. St. Plant Bd. **3**(2) : 47–49.

Found in one nursery and all banana plants there and in adjacent properties were destroyed.

1921. Report of the plant commissioner for the biennium ending April 30th., 1920, and supplementary reports. Quart. Bul. Fla. State Plant Bd. **5**(2) : 94–95.

States that it is also known to attack sugar cane [this is undoubtedly in error]; refers to eradication campaign in Manatee Co. in 1918 and of elimination of an infestations in Polk Co. in 1918; in Dade Co. in 1919 and 1920 several infestations were cleaned up and the State is apparently clean.

Newman, L. J. 1924. Report of economic entomologist. West Austr. Dept. Agr. Ann. Rept. for the year ended June 30, 1924, p. 22.

"Two outbreaks of this weevil were recorded during the year in the North West. In both instances the North-West Department was advised to destroy by fire the whole of the plants. This was done and the outbreaks suppressed. Carnavon District still infested. The Southwest apparently not yet infested."

Ogilvie, L. 1924. Notes on plant diseases and pests. Agr. Bul. Bermuda Dept. Agr. **3**(2) : 6.

Brief note: prevalent wherever bananas are grown in unsuitable soil or are not properly cultivated; attention should be paid to proper cultivation, rotation of crops where possible and systematic trapping with baits of banana stems or bulbs, and traps examined every three days.

1924. Preliminary report of the plant-pathologist for the period September 27th. to December 31st., 1923. Bermuda Repts. Bd. and Dept. Agr. 1923, p. 29.

Briefly stated as only of serious importance where bananas are grown in unsuitable soil or situation or are otherwise weakened.

1928. The Insects of Bermuda. Dept. Agr. Bermuda, [unnumbered publication], p. 16.

"Of serious importance in Bermuda only where bananas are grown in unsuitable soil or situation or where the plants are otherwise weakened."

Pierce, W. D. 1917. A manual of dangerous insects likely to be introduced in the United States through importations. pp. 34, 207. U. S. Dept. Agr. Office of Sec'y.

Brief; life history; also lists sugar cane as a host [undoubtedly in error]; distribution is: Fiji, British West Guinea [in Eastern Hemisphere south Pacific Ocean to Indian Archipelago] Jamaica, India, Brazil.

Pinto, M. P. D. 1928. The two weevil pests of plantains. (Musa sapientum L.) *Cosmopolites sordidus* Germ. and *Odoiporus longicollis* Oliv. Trop. Agr. **70**(4): 216–224, figs. 1–5.

Life-history and control for Ceylon; bibliography of 7 titles.

Pynaert, L. 1921. Les bananiers. Bul. Agr. Congo Belge, **12**(2): 249–251.

Brief general account with suggested control.

Ramakrishna Ayyar, T. V. 1922. The weevil fauna of South India with special reference to species of economic importance. Agr. Res. Inst., Pusa, Calcutta, Bul. 125, p. 19, fig. 1, pl. 20.

"Brief mention of *C. sordidus* as occasionally injurious to the stems of growing banana plants, but noted so far only in Malabar and the Northern Sircars."

1923. Some insects noted as pests of fruit trees in South India. Agr. Jour. India **18**(1): 50–59.

"Tho found in a few places in South India, has not yet assumed the status of a serious pest."

Reh, L. 1913. Die tierischen Feinde, in P. Sorauer's Handbuch der Pflanzenkrankheiten **3**: 566.

Mention.

Ritchie, A. H. 1916. Report of entomologist for year 1915–1916. Ann. Rept. Jamaica Dept. Agr. for year ended 31st. March 1916, p. 33.

"The presence of the black weevil of banana (*C. sordidus* Germ.) in the Island was brought for the first time to the attention of banana planters by the Entomologist in late November, 1915. This insect has already formed the subject of independent and extended report."

* 1916. The black beetle attacking banana cultivations. Daily Gleaner, Kingston, Jamaica, 22nd. January, p. 18, 2 figs.

Brief general account of distribution and injury; cooperation in control urged. (Rev. Appl. Ent. 4: 175, 1916.)

1917. Annual report of the government entomologist for year 1916–1917. Suppl. to Jamaica Gaz. **40**(4) : 97.

Very briefly summarizes a report submitted in December—mention of the beneficial grub of *Pyrophorus* sp. (Elateridae); adults lived in banana trash in the laboratory for 159 days.

1919. Annual report of the government entomologist for 1918–1919. Jamaica Dept. Agr. Ann. Rept. for year ended 31st. Mar. 1919, p. 28.

Note stating that two consignments of *Placsius javanus* from Java were received but most of them died on the way.

Rivera, E. M. 1927. Informe sobre el trabajo de estudios del gorgojo del ñame del banano. Rev. Agr. Puerto Rico **19**(2) : 59–62, 1 fig., 1 map.

Description of a survey to determine the presence and abundance of the insect in three districts in the Island.

Rodríguez Barrera, J. 1928. El banano, pp. 82–83 [Manual del agricultor en Fernando Póo, III, Madrid].

Brief account.

Sasscer, E. R. 1915. Important insect pests collected on imported nursery stock in 1914. Jour. Econ. Ent. **8**(2) : 269.

Records a single specimen in a plant from Brazil, which in several months finally caused the plant to die down.

1916. Important foreign insect pests collected on imported nursery stock in 1915. Jour. Econ. Ent. **9**: 218.

"Plants from the Philippines found to be severely infested."

Schultze, W. 1915. A catalog of Philippine coleoptera. Manila. Philippine Jour. Sci. 11, Sec. D., p. 148.

Listed from Luzon, Mindanao and Palawan.

Seín, Jr., F. 1923. El gorgojo del ñame del guineo. P. R., Ins. Exp. Sta. Circ. 82, 7 pp., 2 figs.

Brief general account.

1929. El gorgojo del ñame del guineo en Puerto Rico. El Mundo (San Juan, P. R.), Oct. 6, p. 15., 4 figs.

Popular account of life history, injuries, and control.

Simmonds, H. W. 1920. Report on mission to Tahiti to investigate the parasites of the coconut scale with a view to their introduction into Fiji. Circ. Info. Fiji Dept Agr. **1**(7) : 137.

Recorded as doing considerable damage in the Cook Islands.

1921. Histerid Beetle, *Plaesius javanus*. Agr. Circ. Dept. Agr. Fiji **2**(3) : 44.

Recovery of *P. javanus* eight years after being introduced.

1922. Coconuts and bananas on certain islands around the coast of Vitilevu. Agr. Circ. Dept. Agr. Fiji **2**(5) : 102–104 (1921).

Generally present but not very injurious; worse where dry than where wet.

1922. Introduction and notes. Agr. Circ. Dept. Agr. Fiji **2**(5) : 111 (1921).

Very injurious at Nasinau; trapping stated to be fairly effective.

1922. Visit to Fotuna and Wallis Island. Agr. Circ. Dept. Agr. Fiji **3**(2) : 20.

Reported as not present.

1922. Entomological Division. Dept. Agr. Fiji Ann. Rept. for the year 1921. Council Paper 56, p. 7.

Poor condition of banana industry largely due to attacks of weevil; trapping caught large numbers of the weevils; believes *P. javanus* now established.

1923. Report by the government entomologist. Dept. Agr. Fiji Ann. Rept. for the year 1922. Council Paper No. 46, p. 4.

Additional specimens of *P. javanus* recovered in the field.

* 1924. Report on Mission to New Guinea, Bismarks, Solomons and New Hebrides. Legislative Council Fiji, Council Paper, Suva, February.

Reported as abundant in New Hebrides. (Rev. Appl. Ent. 12: 300, 1924.)

1929. Some experiments to ascertain the part played by flight in the dispersal of the banana borer, *Cosmopolites sordidus* in Fiji. Agr. Jour. Dept. Agr. Fiji, **1**(3) : 22–26 (1928).

Flight very occasional and a negligible factor in dispersal.

* **Small, W.** 1921. Annual report of the acting entomologist for 1919–20. Uganda Dept. Agr. Ann. Rept. 1919–20, p. 41.

Statement that inquiries had been received with reference to *C. sordidus*. (Rev. Appl. Ent. 9: 319, 1921.)

Smith, F. E. V. 1929. Report of the acting government entomologist. Ann. Rept. Jamaica Dept. Agr. for year ended 31st. Dec. 1929, p. 20.

Continues troublesome, especially in "ratoon" fields; paradichlorobenzene not so satisfactory as previousy expected.

Smith, R. C. and **Audant, A.** 1930. The more important injurious insects of Haiti. Jour. Econ. Ent. **23**(6) : 976.

"Widely distributed and serious."

* **Sturm, J.** 1826. Catalog meiner Insecten-Sammlung. (Verzeichniss der. . . vörrathigen Insecten) Thl. 1. Nürnberg. Käfer. pp. VIII, 207 (16), 4 pls. Col., 8°.

Swezey, O. H. 1924. Notes on insect pests in Samoa. Hawaiian Planters' Rec. **28**(2) : 217–218.

Brief; the insect probably only recently established and not as yet generally distributed; injury briefly described; serious in Fiji and control difficult.

Torres, I. L. 1927. El gorgojo del ñame del guineo (*Cosmopolites sordidus*). Rev. Agr. Puerto Rico **9**(2)56–58, 2 figs., August.

General popular account for Porto Rico.

Tryon, H. 1917. Report of the entomologist and vegetable pathologist. Queensl. Ann. Rept. Dept. Agr. & Stock for 1916–1917, p. 51.

Brief statement of distribution in Queensland; has occasioned proclamation of a special Regulation for its suppression but still very prevalent locally.

1920. The banana weevil (*Cosmopolites sordida* Chevr.). Considerations influencing methods of repression. Queensl. Agr. Jour. **13**(5): 222–223.

Good description of methods of use of (*a*) traps, (*b*) removal of infested suckers, (*c*) destruction of beetles by starvation, (*d*) reducing egg-laying.

Tryon, H. and **Benson, A. H.** 1920. The banana weevil (*Cosmopolites sordida* Chevr.) Queensl. Agr. Jour. **13** (4): 165–168, 5 figs.

Brief general account.

* **Urich, F. W.** 1916. Insect pests in Trinidad. Entomologist's Rept. Minutes Meet. Bd. Agr. Trinidad, pp. 1–56.

Reported from some localities in Trinidad; recommends destruction of infested stools, ploughing, forking and liming land; the Histerid beetle will be tried. (Rev. Appl. Ent. 5: 171, 1917).

* 1925. The plantain weevil. Bul. Dept. Agr. Trinidad and Tobago, **21**(1): 40–42, 1 pl.

General account for Trinidad; the usual control measures recommended, including submerging suckers in water for 48 hours (Rev. Appl. Ent. 14: 176, 1926).

Veitch, Robert. 1926. Report of the chief entomologist. Ann. Rept. Dept. Agr. and Stock Queensland for 1925–1926: 135.

Mention of publication of complete account as Bul. 4 and four introductions of *Plaesius javanus* noted.

1927. Report of the chief entomologist. Ann. Rept. Dept. Agr. and Stock Queensland for 1926–1927: 69.

Brief mention of history of investigations; trapping with Paris green baits best; *Plaesius javanus* introductions apparently established.

1928. Report of the chief entomologist for year ending June 30, 1928. Dept. Agr. and Stock Queensland (as a separate publication of 8 pp.), p. 1.

Mention of Frogatt's trip to Java to import the predators—*Chrysopila ferruginosa* Weid. and *Plaesius javanus* Er.

Veitch, R. and **Simmonds, J. H.** 1929. Pests and diseases of Queensland fruits and vegetables. Queensland Dept. Agr. and Stock, pp. 106–112, pls. 26 and 27.

Full account.

Walters, E. A. 1926. Control of insect pests. Rept. Agr. Dept. St. Lucia, 1924, p. 9.

Widely distributed throughout the Colony and attacks all kinds of bananas; digging out and chopping up infested stools and soaking in lime water for 48 hours were both used.

1926. Viability of the weevil (*Cosmopolites sordidus* Germar) and the banana borer (*Tomarus bituberculatus* Beaud.) Rept. Agr. Dept. St. Lucia for 1925, p. 8.

Immersing weevils for 48 hours in water not effective; soaking infested plants in lime water for 48 hours recommended and has been adopted.

Ward, F. S. 1930. Banana growing in Malaya and the presence of diseases. Malayan Agr. Jour. **18**(2) : 70.

Greatest damage on poor soils; refers to suggestion of Dr. Wardlaw who thinks this insect may be an important accessory factor as a wounding agency in connection with Panama disease and refers also to experiments of Dr. Wardlaw of Imp. Col. Trop. Agr. (Trinidad) that innoculation experiments show that the borer enters the rhizome after the disease is established.

Watts, Sir Francis. 1917. Banana borer. Jour. Jamaica Agr. Soc. **21** : 169–173.

Description by the Commissioner of Agriculture of W. Indes of distribution in St. Andrews section, injury, etc., of weevil; contends attacks primarily weakened plants; need thoro survey and research.

Whitney, L. A. 1927. Report of the division of plant inspection, January 1925—December 1926. Rept. Bd. Agr. & Forestry Hawaii 1925–1926, pp. 48–57.

Brief note recording interception on abaca plants (*Musa textilis*) from the Philippines.

Wolcott, G. N. 1922. Informe anual de la división de entomología para el año fiscal de 1921 a 1922. Informe An. Est. Exp. Ins. Río Piedras, Puerto Rico, 1921–1922, pp. 59–60. (Also in English ed., pp. 48–49, 1923.)

Brief account of discovery in Porto Rico (Dec. 1, 1921); life history, injury and control.

1922. Vaquitas de importancia económica en Puerto Rico. Porto Rico Ins. Exp. Sta. Circ. 60, pp. 11–12, 2 figs.

Brief description of injury; recommends attracting and destroying weevils by means of freshly sliced rhizomes.

1924. Entomología económica puertorriqueña. Est. Exp. Ins. Puerto Rico Bol. 32: 58–59.

Brief general account.

1924. Insectae portoricensis. Jour. Dept. Agr. Porto Rico **7**(1): 135 (1923).

Listed from several localities in Porto Rico.

1924. Annual report of the division of entomology for the fiscal year 1922–23. Ann. Rept. Ins. Exp. Sta. Porto Rico, fiscal year 1922–3, p. 55.

Experiments interrupted but preliminary results indicate that daily collections from traps must be continued for several months before improvement of plants is shown.

1926. Insect pests in Haiti. Internat. Rev. Sci. & Pract. Agr. N. S. **4**(1): 188.

"Bananas are attacked by the root borer, *Cosmopolites sordidus* Germar.

1927. Entomologie d' Haiti. Published under the direction of the Service Technique, Dept. Agr. Haiti, pp. 253–256, 391–392, 2 figs.

Brief general account; generally distributed thruout Haiti.

THE EFFECT OF MOSAIC ON CELL STRUCTURE AND CHLOROPLASTS

MELVILLE T. COOK

This is a continuation of previous studies, the results of which were presented at the meeting of American Phytopathological Society, December 1926 and at the DesMoines Meeting of the same society in December 1929 and which have been published in the Journal of the Department of Agriculture of Puerto Rico (Vol. X Nos. 3 & 4, 1926 and Vol. XIV, No. 2, 1930).

In the previous studies the writer called attention to two points in the reaction of the hosts to the disease. (1) The disease inhibits the development of the meristematic tissue so that there is very little or no differentiation after the virus comes in contact with it. (2) The inhibition of the chloroplasts for a time. These points have been discussed to a greater or less extent by other writers previous to my own studies. Woods (1902), Iwanowski (1903), Melchers (1913), Doolittle (1920), Matsumota (1922), Rand (1922), Dickson (1922), Rawlins and Johnson (1925) and Goldstein (1926).

During the past year opportunity was offered to continue this work on other plants and it was thought desirable to do so, in order to determine if the laws held true in all cases.

The first plant for consideration at this time is the pepper which confirms in every detail the results of the writers studies on the tobacco and tomato, except that the process is much more rapid which is in harmony with the growth of the plant. The pepper leaves open and attain full size more rapidly than either the tobacco or tomato and the leaves on the new shoots are much closer together.

These studies were made on several plants. Seven leaves were taken from the one selected for the drawings. The first three did not show the mosaic pattern. The next showed a distinct pattern and in the sixth and seventh chlorotic areas were becoming green and the pattern indistinct. A corresponding series of leaves were taken from a healthy plant.

The section of the first leaf showed an undifferentiated tissue, with very few small chloroplasts (Fig. 1). The second showed the formation of a palisade layer and a larger number of chloroplasts (Fig. 2) while the third showed that some of the palisade cells had

divided which is an indication of a mild form of the disease (Fig. 3). The fourth showed practically the same conditions except that the chloroplasts continued to increase in size and number (Fig. 4) and the mesophyll was slightly better developed. A series of four drawings made from the leaves of the normal plant (Figs. 5 to 8) showed that the youngest leaf was more advanced in cell and chloroplast development than the second leaf from the diseased plants. The second leaf of the normal plant (Fig. 6) was better developed than the fourth leaf of the mosaic plant (Fig. 3). The third leaf of the healthy plant (Fig. 7) was nearly equal to the fifth leaf of the diseased plant. The fourth leaf of the normal plant (Fig. 8) was better developed than the fifth leaf of the diseased plant. In general, it may be said that the results correspond to the results of my previous studies, although not so pronounced.

An outbreak of the mosaic disease on *Crotalaria striata* gave the writer an opportunity to study the effects of the disease on this plant. A series of six leaves were taken from both diseased and normal plants. The results are as follows:

The first and second leaves on all plants studied were unopened and of course did not show the symptoms of the disease. In the section of the first or very youngest leaf of a diseased plant it was possible to distinguish the areas that were to become chlorotic from those that were to become green (Figs. 9 & 10). In the section from the chlorotic areas, the cells were undifferentiated and the chloroplasts few and small (Figs. 9 & 10) while in the sections from the areas that would have become green the palisade was slightly developed and the chloroplasts much more numerous and larger. These two drawings (Figs. 9 & 10) were made from a single section of a leaf. The third leaf of the diseased plants was not open and there was no visible pattern. Two sections from its leaf of the mosaic plant showed an increase in thickness, slight advance in cell structure which was greater in the section from the green area (Fig. 12) than in the section from the chlorotic area (Fig. 11) and a much greater development of chloroplasts in the green than in the chlorotic area. The development of both cell structure and chloroplasts was more advanced in the corresponding leaf from the normal plant than from the green area of the diseased plant.

The seventh leaf of the mosaic plant was open and the pattern distinct. The section (Fig. 13) from the chlorotic area was thin, the palisade very poorly developed, the mesophyll open, the chloroplasts few and about normal in size when compared with the chloro-

plasts of the normal leaf. (Fig. 14). The section (Fig. 15) from the green area of the diseased leaf was thicker but the cell structure showed the effects of the disease in the porly developed palisade. The chloroplasts were more numerous than in the chlorotic section (Fig. 13) but fewer than in the section from the normal leaf (Fig. 14). The ninth leaf of the diseased plant (Fig. 16) was thin, the palisade almost undeveloped but the chloroplasts were larger and more normal. The section from the green area was almost normal in every particular.

The papaya (*Carica papaya* L.) is a plant of the tropics and near tropics. A few years ago I noticed a disease of this plant on the station grounds, but the gardener destroyed it before I had time to study it. This or a similar disease was reported later by Dr. Ciferri of Santo Domingo under the name of curly leaf. Both Dr. Ciferri and myself are in doubt as to the exact cause of this disease but I am inclined to believe that it is due to a virus. A comparison of a section of a very young diseased leaf (Fig. 17) with a section of a very young normal leaf (Fig. 18) shows that the diseased leaf is thinner than the normal leaf and that the palisade is not so well developed. Passing to the fifth leaf of the diseased plant (Fig. 19) and the fifth leaf of the normal plant (Fig. 20) we find that the diseased leaf is about one-half as thick as normal leaf and not so well developed. The chloroplasts of the diseased leaf at this stage are almost equal to the chloroplasts of the normal leaf.

Two monocotyledonous plants were studied. The Amazon lily (*Eucharist amazonica*) and a hybrid Amarillis. The results of the studies on these plants were so nearly the same that drawings were made from the first one. It was impossible at the time this material was collected to find any plants that were not diseased. Therefore the sections are made from the chlorotic and the green areas of diseased leaves. These plants produce two or three leaves in rapid succession and then rest for a few months before producing another cluster. Two clusters are usually to be found on a plant. The material from which these studies were made was collected immediately following the unfolding of the youngest leaf of a new cluster and was from the three young and two old leaves.

The section from the chlorotic area of the youngest leaf was thinner than the section from the green area and without chloroplasts. The section from the green area of the same leaf showed many small chloroplasts (Figs. 21 & 22). The sections from next leaf were

thicker than those from the first leaf but the one from the chlorotic areas was thinner than the one from the green area. Both sections showed chloroplasts but they were more numerous in the thick than in the thin area (Figs. 23 & 24). In the third leaf both areas were thin but the section from the green area showed a higher development in that there were numerous intercellular spaces. Also the chloroplasts in the green area were larger and more numerous than in the chlorotic area (Figs. 25 & 26).

The two older leaves were less succulent than the three young leaves and the sections showed that they were thinner. In both old leaves the sections showed more chloroplasts in the green than in the chlorotic areas but for some unexplained reason those of the green areas were slightly smaller than those from the third leaf of the new cluster.

EXPLANATION ON PLATES

Fig. 1.—Section from youngest leaf of mosaic pepper.

Fig. 2.—Section from second leaf of same plant.

Fig. 3.—Section from the third leaf of the same plant. Note the divisions in three of the palisade cells which indicates a mild form of the disease and the increase in number and size of chloroplasts which is probably the result of age and exposure to sunlight.

Fig. 4.—Section from the fourth leaf. Note that palisade is not so well developed as in the normal leaf (Fig. 8). Also note the increase in the size of the chloroplasts as compared with Fig. 3.

Figs. 5 to 8.—Sections from the four youngest leaves of a healthy plant for comparison with the corresponding leaves of the diseased plant (Figs. 1 to 4).

Figs. 9 & 10.—Sections from the chlorotic areas of a young leaf of a mosaic plant of *Crotalaria striata*. Note that Fig. 10 is better developed than Fig. 9.

Fig. 11.—Section from the chlorotic area of the next older leaf of the same plant.

Fig. 12.—Section from the green area of the same leaf. Note the greater development in both cells and chloroplasts.

Fig. 13.—Section from the chlorotic area of the seventh leaf of the same plant.

Fig. 14.—Section from the seventh leaf of a healthy plant.

Fig. 15.—Section from the green area of the same leaf as Fig. 13.

Fig. 16.—Section from the chlorotic area of the ninth leaf of the diseased plant.

Fig. 17.—Section from a very young diseased leaf of *Papaya carica.*

Fig. 18.—Section from corresponding leaf of a healthy plant.

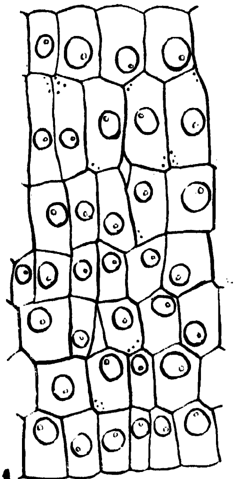
Fig. 19.—Section from an older leaf of a diseased plant.

Fig. 20.—Section from a corresponding leaf of a healthy plant.

Figs. 21, 23 & 25.—Sections from the chlorotic areas of a diseased plant of *Eucharist amazonica.*

Figs. 22., 24 and 26.—Sections from the green areas of the same leaves.

PLATE IX.



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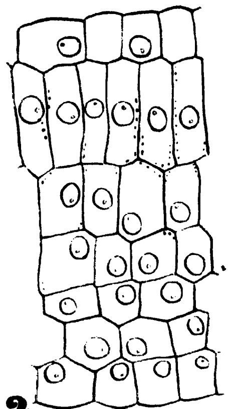

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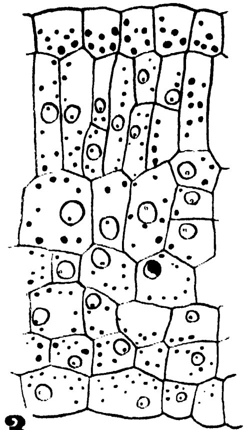

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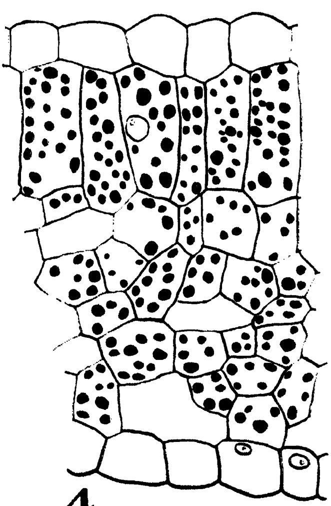

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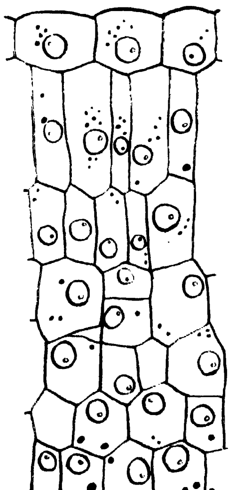

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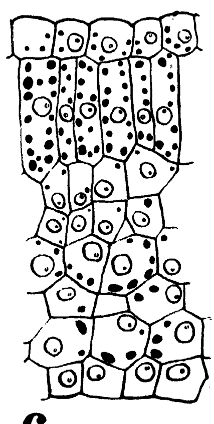

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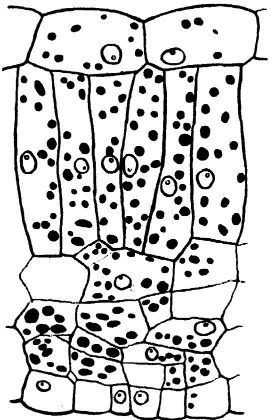

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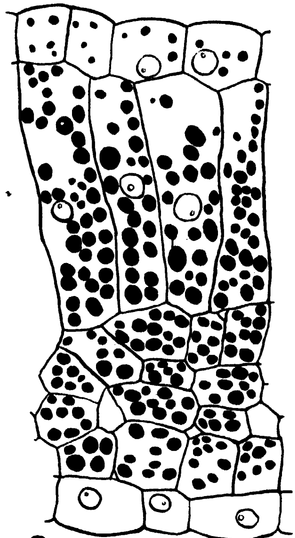

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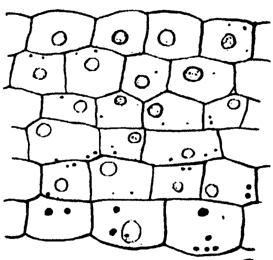

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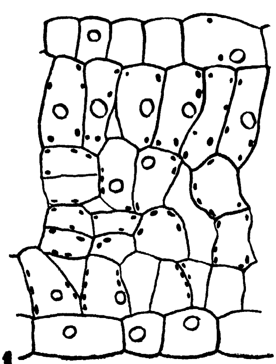

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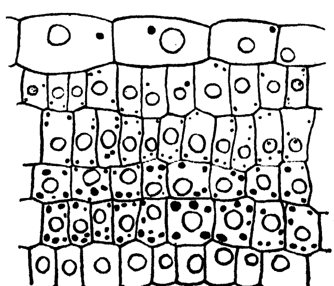

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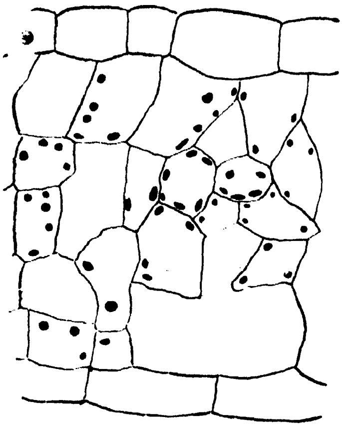

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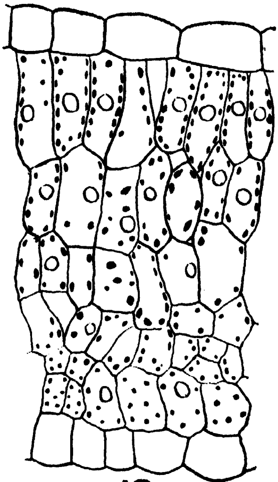

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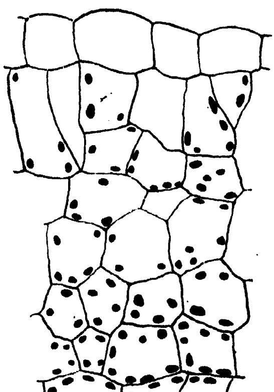

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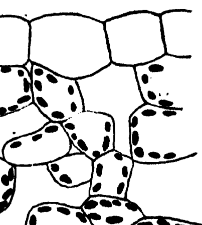

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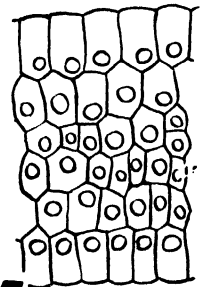

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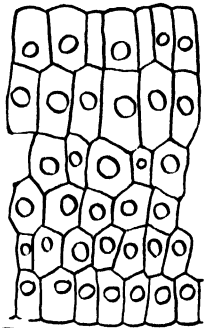

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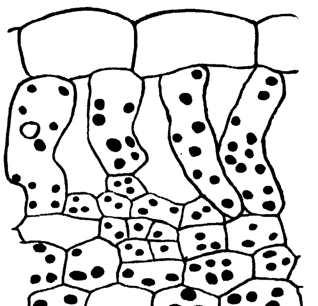

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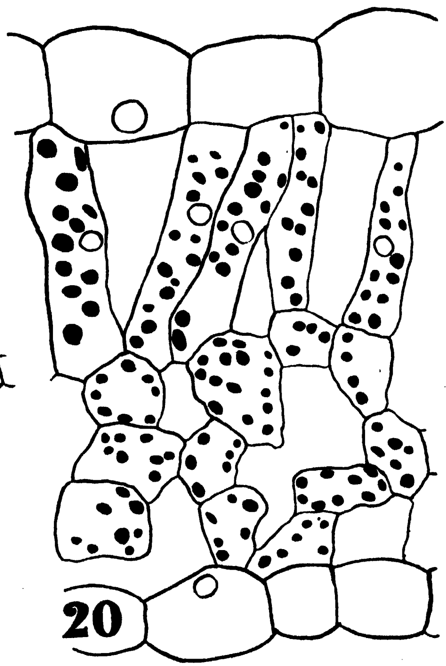

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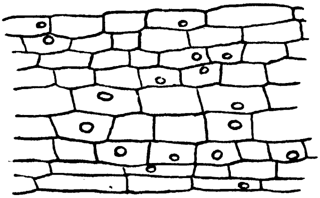

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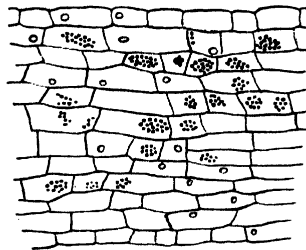

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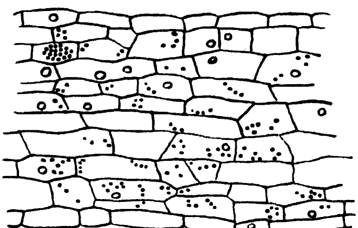

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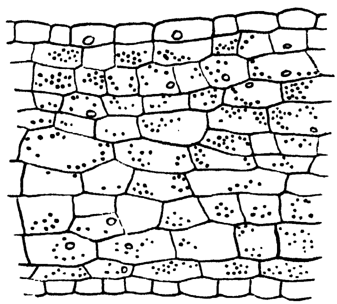

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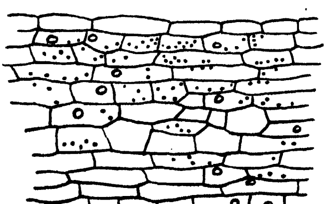

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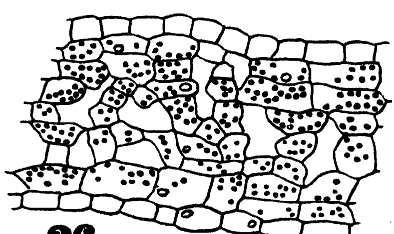

26

THE LEAF SPOT OF TOBACCO; AN AFTER SYMPTOM OF MOSAIC

MELVILLE T. COOK

Soon after coming to Puerto Rico in 1923 the attention of the writer was called to a peculiar spotting on the leaves of tobacco. Collections of these spotted leaves were sent in from time to time and were examined for fungi and bacteria but the results were always negative. The disease appeared to be of minor importance and no special studies were made until the winter of 1929–30. These spots were always on the mature, usually the lower, leaves of the plants. They were 2 to 5 mm. in diameter, white, brown or black and composed of dry, dead tissues. During the winter of 1929–30 great numbers of these spots were found one morning in tobacco mosaic experimental plots. These plots were not more than 50 feet from my laboratory and it was my habit to visit them nearly every day. Therefore, it was evident that these spots developed in a very short time. A careful examination showed that these spots were on the mosaic plants and not on the healthy plants and that they were always on the old leaves which did not show the symptoms of the mosaic, *i. e.* on leaves, which due to late inoculations, had not developed the symptoms or on leaves from which the pattern had disappeared. The following morning the spots were much more numerous. Plants which did not show these spots were marked and observed from day to day and it was soon learned that plants which did not show those spots one day might show a considerable number the following morning. A block of plants was then divided into two parts and the plants in one part inoculated. In due time the spots appeared on old leaves of the diseased plants.

These spots remind one of the early studies by Mayer, Iwanowski and others. Mayer (**10**) reported a spotting in the late stages of the tobacco mosaic. Iwanowski stated that Mayer had confused two diseases and that the spots were a disease which had been described by himself and Polowzoff under the name of "pockenkrankheit".

He says:

"This last name I retain for that disease which is the subject of this paper, and as I have just described it *never manifests itself in the form of dry spots.*"

In 1894 Prillieux and Delacroix described spotting of the leaves

of the tobacco under the name of "nielle" and from which they claimed to have isolated a motile bacillus. Some workers have supposed that this disease was the same as Mayer's "mosaikkrankheit" but this is extremely doubtful.

In 1897 Marchal described a disease under the name of "La Mosaique du Tabac" which was probably the same as the disease described by Mayer. He emphasized the presence of the spots which he also described as containing a motile bacillus.

In 1898 Beijerinck published a paper on tobacco mosaic in which, judging from the description, there is no doubt that he was studying the mosaikkrankheit of Mayer. One of his illustrations shows a spotting which is the same or similar to the spotting described by Mayer and others.

In 1898 Sturgis of Connecticut published a preliminary note on two diseases of tobacco in which he said:

"If allowed to remain, the paler portions of the mottled leaf loss their green color and the whole leaf becomes yellow and sprinkled over, especially towards the tip, with small circular spots where the tissues are bleached dead and brittle."

Later on in the same paper he says:

"If that can be called a disease which is characterized by symptoms such as tobacco-growers desire to see in moderation, which enhance the market value of the leaf and which can be induced artificially with profit, then the 'spotting' of tobacco comes under this head. It is a peculiar disease, never very common, nor confined to any one locality and not characteristic of any special soil. What its earliest stages are I am unable to say, inasmuch as it is imposible to predict when it will occur and therefore to be on the watch for its first appearance, and, furthermore, because it only becomes noticeable when well advanced. As I have seen it in the field and in specimens sent to the Station, it is signalized by the presence on the leaf of small circular spots. These usually occur in the greatest number at or near the tips of the leaves and, at first, are yellowish in color and somewhat irregular in outline. Later they take on a circular form and become marked off from the surrounding tissue by a narrow border of a darker color. The tissue within this border finally dies and becomes almost white, but, except in severe cases, it does not break away from the leaf. A leaf so affected looks as though it had been sprinkled over with some caustic substance which has killed the tissues without disintegrating them. It bears a close resemblance also to the 'leaf-spot' caused on certain plants by the attacks of fungi. Sometimes the spotting is slight and the spots themselves are scattered evenly over the whole leaf-surface; in such cases buyers are willing to pay a higher price for tobacco, spotted wrappers being in demand. The spot can be successfully imitated by spraying the ripening leaves with a caustic liquid, and, where this is well done, the tobacco also brings a higher price.

"It is only when the spot invades practically the whole leaf and causes the breaking of the tissues that it does serious damage. I have already repeatedly, but thus far unsuccessfully, attempted to discover the primary cause of this

trouble both by consulting the opinion of experienced tobacco-growers and by careful microscopic examination of the spots. Some say that it is to particles of sand adhering to the leaves; others that it is caused by drops of water, which, acting as lenses, burn the leaf where they rest; but with regard to these theories it is sufficient to say that they have been put to proof in many attempts to produce the spot artificially and have signally failed. Scores of the spots have been microscopically examined during the past three years without showing any evidence of the presence of fungi, insects or bacteria. Nothing further, therefore, can be said regarding this trouble, nor would it have been considered worthy of mention at present were it not for its resemblance to a disease of tabacco which occurs in Europe and Asia.''

In 1902 Woods referred to a spotting of mosaic tobacco leaves which he described as follows:

''In field conditions as a final stage the swollen green area became marked with small dead spots, but these did not appear in plants grown under glass.''

In 1914 Clinton reported a spotting of mosaic tobacco leaves which he described as:

''A serious leaf injury known locally as 'rust' often occurs on the older calicoed leaves. It shows as small, roundish, reddish-brown spots of dead tissue, more or less thickly covering the leaves; sometimes these merge into large irregular areas, resembling sun scorch injury of the plants. This is probably the same trouble described by various European writers as 'pockenkrankheit', ascribed by some to bacteria. In this state rust is not a necessary accompaniment of calico, but rarely if ever occurs except on leaves showing calico or signs of suppressed calico. We believe that it is of the nature of sun scorch, since it usually occurs in bright, hot weather, suddenly following a rainy or cloudy period, and that it develops on calicoed leaves because of their weakened conditions.''

Material from these spots and the surrounding tissues was prepared for embedding and sectioning. The writer was especially interested in this work because of his previous studies which led to the conclusion that the chlorotic areas were the result of inhibition and disintegration of the chloroplasts.

A careful study of both free hand and microtone sections of these spots showed that the spots originated in the palisade cells (Figs. 1 to 8). It was impossible to determine whether they originated as small spots which gradually enlarged or whether the spot was full sized from the beginning but the fact that the spots develop during a single night indicates that they are full sized from a very early stage in their formation. The sections revealed many spots which consisted of a single cell and which could not be detected with the unaided eye (Fig. 2). Others ranged from small groups of a few cells (Figs. 1 to 9) to areas 5 mm. or occasionally more in diameter. The dying of the palisade cells is followed

by a dying of the cells below. This usually continues until all the cells from the upper to the lower surface are dead (Figs. 5 to 10). It appears that the palisade and upper epidermal cells may be the only dead cells of the spots on the morning of the first day and that the lower cells die later. Occasionally dead mesophyll cells are found in positions unrelated to the spots.

Efforts were made to study the disintegration of the cell contents but very little was learned about it probably due to the fact that it appears to break down during the night. However, the entire cell content appears to disintegrate into a homogenous black mass which dries and shrinks from the cell wall. The next step in this process is the collapse of the upper epidermis (Figs. 6, 7, 8, 9). The next step is the breaking of the cell walls throughout the entire area (Figs. 7, 8, 9). The final step is the contraction and drying so that the entire area becomes thin, dry and brittle (Figs. 9 & 10).

A careful study of other tobacco plants has shown similar spots on leaves of plants with other diseases and on leaves that were past maturity, but these were not so common or so abundant as on the mosaic plants. A few spots were also on leaves of pepper plants which had been inoculated with the tobacco virus.

Note: Since the preparation of this manuscript for publication, Johnson and Hoggan have published a paper (**8**) in which they say:

> "Soon after Mayer's work became known, it was claimed by some that his 'Mosaikkrankheit' of tobacco included two distinct diseases, one the true infectious mosaic and the other a supposedly unrelated disease known elsewhere as 'Pockenkranheit'. Although much attention was given to the subject, this disagreement has presisted almost to the present time, though it is now quite generally conceded that Mayer was correct in his interpretation that necrosis is one of the symptoms of the ordinary tobacco mosaic virus on tobacco as well as on certain other hosts."

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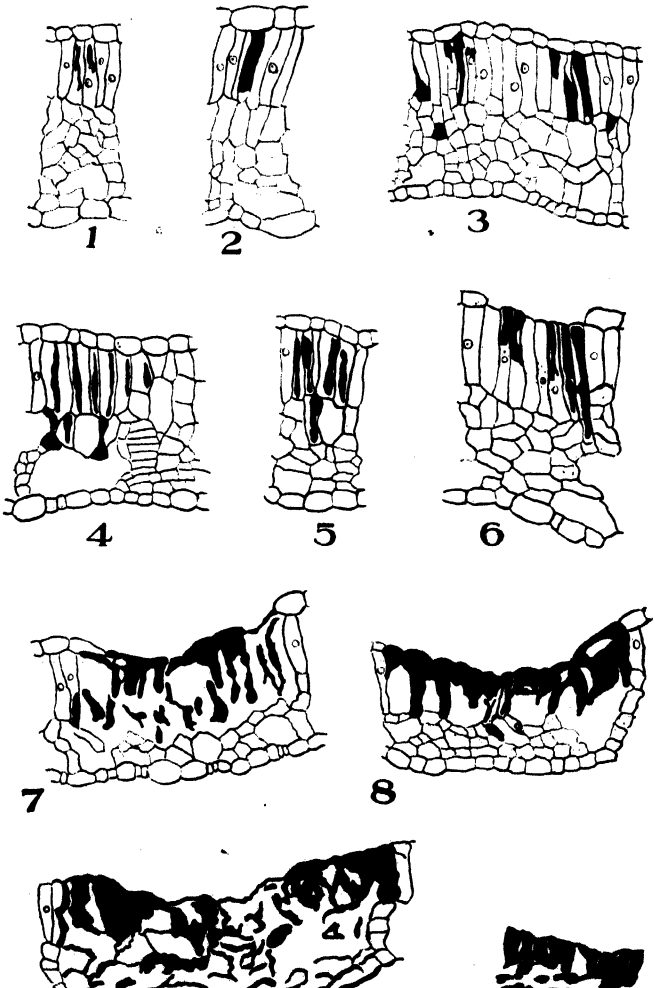
PLATE XIV.



SOME UNDESCRIBED SYMPTOMS OF MOSAIC IN PORTO RICAN TOBACCO

MELVILLE T. COOK

In discussing the symptoms of mosaic in plants, it is necessary to take into consideration many factors, such as:—the host, the strain of virus and the environment. It is well known that the symptoms resulting from the use of a definite virus on different species within a genus or sometimes on varieties within a species may be different or that the host may be a symptomless carrier of the virus. It is also well known that the symptoms vary with the strain of the virus and with environmental conditions. It should also be remembered that the response of the host to the disease may vary with the age of the host and with the rate of growth and that the rate of growth depends in a great measure on the environment.

It is very generally recognized, although not emphasized in the literature that the symptoms may undergo changes with age. The symptoms of mosaic in many plants are usually well defined on the younger leaves but the chlorotic areas gradually become green with age, so that it is impossible to distinguish the patterns on the older leaves.

Unfortunately some of the workers, following the lead of Beijerinck, Koning and other early investigations have persisted in assuming that the chlorotic areas in mosaic plants were the results of a disintegration of the chloroplasts although if this were the case the chlorotic areas should become more chlorotic with age instead of becoming green as is the case in the common mosaic of tobacco, sugar-cane and many other plants. It has also been assumed that the chlorotic areas increase in size as a result of the invasion of the green areas by the virus from the chlorotic areas. Both of these ideas have been contradicted by the writer in previous papers. In many of the mosaic diseases, the chlorotic areas gradually become green with age, the leaf may become uniformly green and the mosaic pattern disappears. The writer has expressed the opinion as a result of the study of several mosaic diseases that the chlorotic areas are not due to desintegration of the chloroplasts but to an inhibition of their development. Later in the growth of the leaves this inhibition is overcome and the chloroplasts increase in size and number. The writer has also expressed the opinion that

the chlorotic areas do not increase in size as a result of the invasion of the surrounding cells by the virus but that the increase in size is a result of cell growth and division. However, my statements have not applied to the lesions which are characteristic of some of the virus diseases because I have had no opportunity to study them.

The tobacco mosaic of Porto Rico may be described as the common type in which we find irregular green and white areas. In some cases there is the blistering or pocketing which has been described in many publications but this symptom is not prominent. In very severe cases the entire plant may be a light yellow or almost white, the leaves small, rather brittle and the margins turned down. There are several modifications of the pattern but thus far the writer has been unable to separate these types and for the present must consider them as symptom variation due to the same virus. This virus will also produce mosaic on tomatoes and pepper and when transferred back to tobacco the symptoms are the same as on the original tobacco plant from which the virus was obtained. It can also be transferred between tomato and pepper and will give the characteristic symptoms on each. The symptoms on the tomato are a slight reduction in size of the leaves, a mottling and the reduction of some of the basal leaflets to short spurs consisting of little more than a midrib.

When tobacco plants are inoculated with a hypodermic needle, inserted at the node, the symptoms appear in from five to ten days, occasionally earlier on the very young leaves. These inoculations were made at various heights on the plants. The typical symptoms developed on the new foliage at the top of the plant and on new shoots at any point on the plant. However, it is the symptoms on the older leaves which were formed previous to inoculation to which the writer wishes to call your attention at this time.

If the mosaic is a disease of the meristematic tissue as stated by various writer in the past or to state the case from the more modern view point, if the meristem is the only tissue that responded to the influence of the virus, will symptoms be developed in the leaves in which the tissues were fully differentiated? These experiments indicated that the typical symptoms rarely developed on the old leaves, that is the leaves that had reached their full size did not show any symptoms; and that the symptoms on leaves that were not quite full sized at time of inoculation, but in which the tissues were fully differentiated sometimes developed more or less circular areas which are sightly lighter in color that the surrounding parts of the leaves. This was due to the inhibition of the chloroplasts.

The effect of direct inoculation into the mesophyll of the leaves was tested by the following method.

Leaves ranging from one to two inches in length were inoculated by rubbing with cheese cloth soaked in juice from a mosaic plant. In from five to ten day's circular spots about ten to twelve millimeters in diameter appeared. These spots were slightly lighter in color than the other parts of the leaf. When these leaves were held to the light, similar areas could be detected in other parts.

The tobacco plants of fifteen leave's each were inoculated by rubbing the leaves on one side of the plant with cheese cloth soaked in juice from mosaic plants. The leaves were measured at time of inoculation and later to determine which, if any, had made their full growth. In five days three of the inoculated leaves on one plant and four on another plant developed areas a's described. Five leaves on the third plant developed symptoms in six days. This experiment was repeated several times with similar result's. Symptoms were very rarely developed on the uninoculated leaves. No spots appeared on leaves that were full sized before inoculation.

A study of the histology of the leave's of different ages showed (1) that when the tissues were not fully differentiated at time of inoculation, there was an inhibition of the development of both cell structure and chloroplasts and that the younger the leaves the greater the inhibition; (2) that when chlorotic areas were formed on leaves in which the ti'ssues were fully developed, there was no change in cell 'structure but that the development of the chloroplasts had been inhibited; (3) that the enlargement of these areas which occurs on the young leaves is due to cell division and cell growth and not to an invasion of the surrounding cells by the viru's. Chlorotic areas did not appear in leaves that had reached full size previous to the inoculation.

NEW VIRUS DISEASES OF PLANTS IN PORTO RICO

Melville T. Cook

During the past year six previously unreported virus diseases have been studied by the writer but some of them had been observed previous to this time. Descriptions are published at this time for the purpose of record and the convenience of the workers.

The mosaic of *Crotalaria striata* DC, is becoming quite abundant in Porto Rico. The patterns are well defined mosaics of dark and light green in which either color may predominate. In some cases the leaves are almost entirely light green or yellow. Occasionally plants are dwarfed by the disease. Severely diseased plants produce few or no seeds. Tests with seeds from diseased plants have thus far given healthy plants. Field observations indicate that the disease is carried by insects. Well advanced plants that have not shown symptoms of the disease frequently develop the disease in the new growths. The writer has demonstrated that the disease can be transmitted by inoculation with juice from diseased plants.

The mosaic of *Commelina longicaulis* Jacq., was first found on the little island of Vieques. This plant grows as a weed in many of the West Indies. The symptoms are rather large chlorotic areas, sometimes forming rings. The infected plants are as vigorous as the healthy and the symptoms do not appear unless the plants are making a vigorous growth. The symptoms disappear during periods of dry weather.

What appears to be a virus disease of *Carica papaya* L. attacked the plants in the Station grounds a few years ago but the gardener destroyed the plants before the writer could make a study of them. This or a similar disease was later described by Dr. R. Ciferri of Santo Domingo as "curly leaf" but he was uncertain as to the cause. My histological studies indicate that it is a virus disease. The young leaves become more or less curled and in severe cases, this curling persists throughout the life of the plant. The lower leaves become yellow and fall. One or both symptoms may appear on the plants. Sometimes all the older leaves fall, leaving a cluster or rosette of leaves at the apex. In severe cases the fruits are reduced in number and size.

Abutilon hirtum (Lam.) Sweet, is a wild species of Malvaceae which shows a high percentage of diseased plants. The patterns

vary and the chlorotic areas are yellowish or white. The diseased plants are usually smaller than the healthy plants but many of them are full sized and do not appear to be injured by the disease. The diseased plants produce very few seeds. The writer has collected and sown a considerable member of these seeds but thus far the seedlings have not shown any symptoms of the disease. Field observation show that it spreads from plant to plant and indicate that it is carried by insects. This disease is interesting because of the fact that the variegated Abutilons which became so popular as ornamentals in Europe about seventy years ago are said to have come from the West Indies.

A mosaic disease is very common on *Sida carpinifolia* L. and *S. rhombifolia* L. and has the same characteristics as the one on *A. hirtum* and may be due to the same virus. This disease is abundant and the diseased and healthy plants may be found growing in contact.

Andenoropium gossypifolium (L.) Pohl. is subject to mosaic which is very common. The chlorotic areas are numerous, variable in size and form, frequently coalescing but very rarely covering the entire leaf. The chlorotic areas grow slower than the green parts which results in slight puckerings.

Ipomoea nil (L.) Roth, which grows abundantly throughout the island is subject to a mosaic which varies from a slight mottling with yellowish or almost white areas to leaves which do now show any of the green color.

Mr. Francisco Seín, Jr., Assistant Entomologist has called the attention of the writer to a mottling of the mulberry leaves. This disease appears as a mottling very characteristic of the mosaic. A second patter which appears as zigzag lines across the leaves may be due to the same cause. Mr. Seín tells me that he has transmitted this disease by means of scions.

EXPLANATION OF FIGURES

Figure 1.—Healthy and Mosaic leaves of *Crolataria striata*.

Figure 2.—Mosaic leaves of *Commelina longicaulis*.

Figures 3 & 4.—*Carica papaya* plant showing effect of a virus disease.

Figure 5.—Advanced stage of *Carica papaya* with a virus disease.

Figure 6.—A very small plant of *Carica papaya* dwarfed as a result of a virus disease. Note the normal plants on either side.

Figure 7.—Diseased leaf of *C. papaya*.

Figure 8.—Healthy leaf of *C. papaya*.

Plate No.——. One healthy and seven mosaic leaves of *Abutilon hirtum.*

Figure 9.—Mosaic leaves of *Sida carpinifolia.*

Figure 10.—Mosaic leaf of *Andenoropium gossypifolium.*

Figure 11.—Mosaic leaf of *Ipomoea nil.*

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PLATE XV.

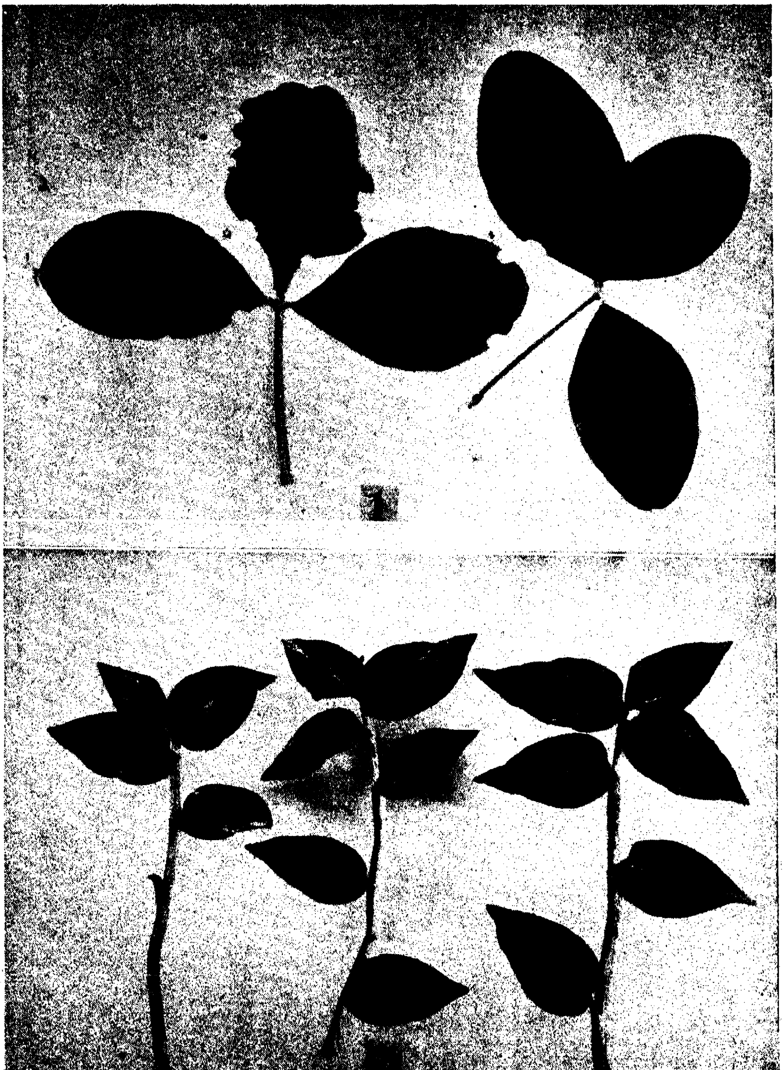


PLATE XVI.

PLATE XVII.

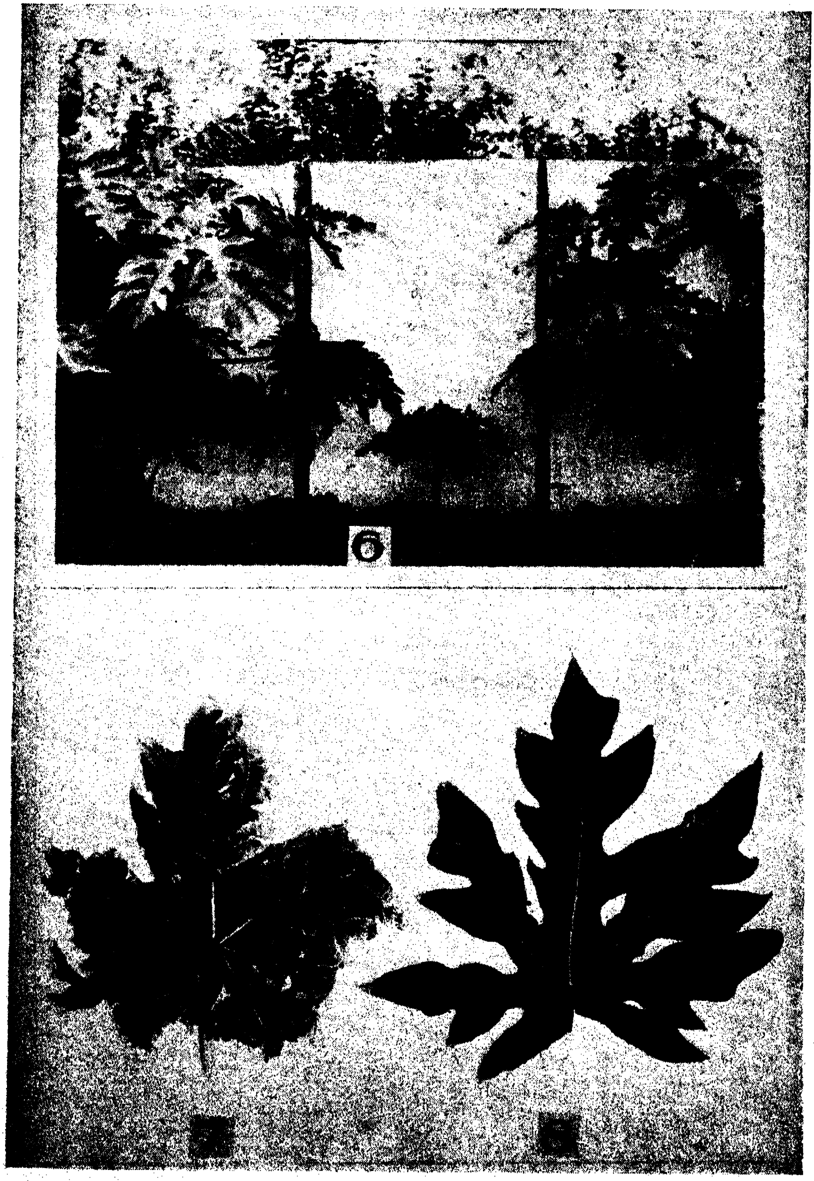


PLATE XVIII.

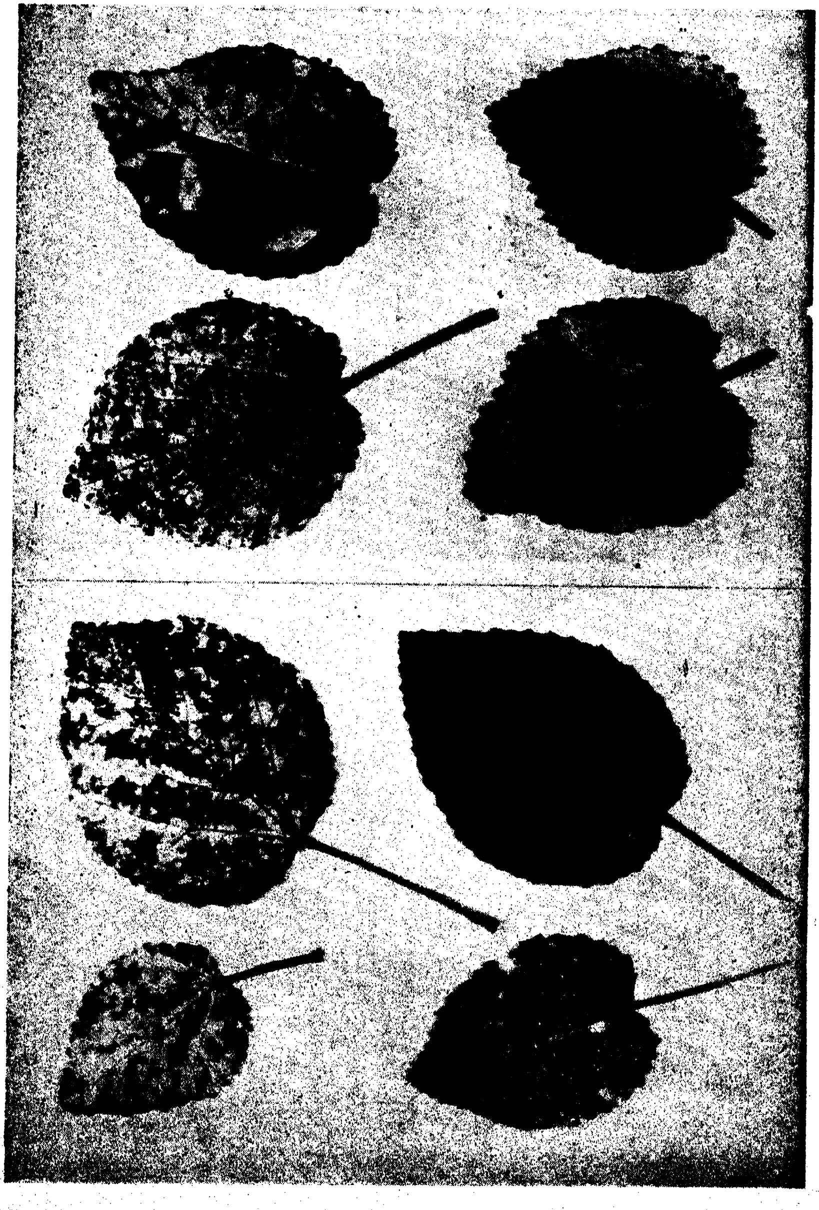
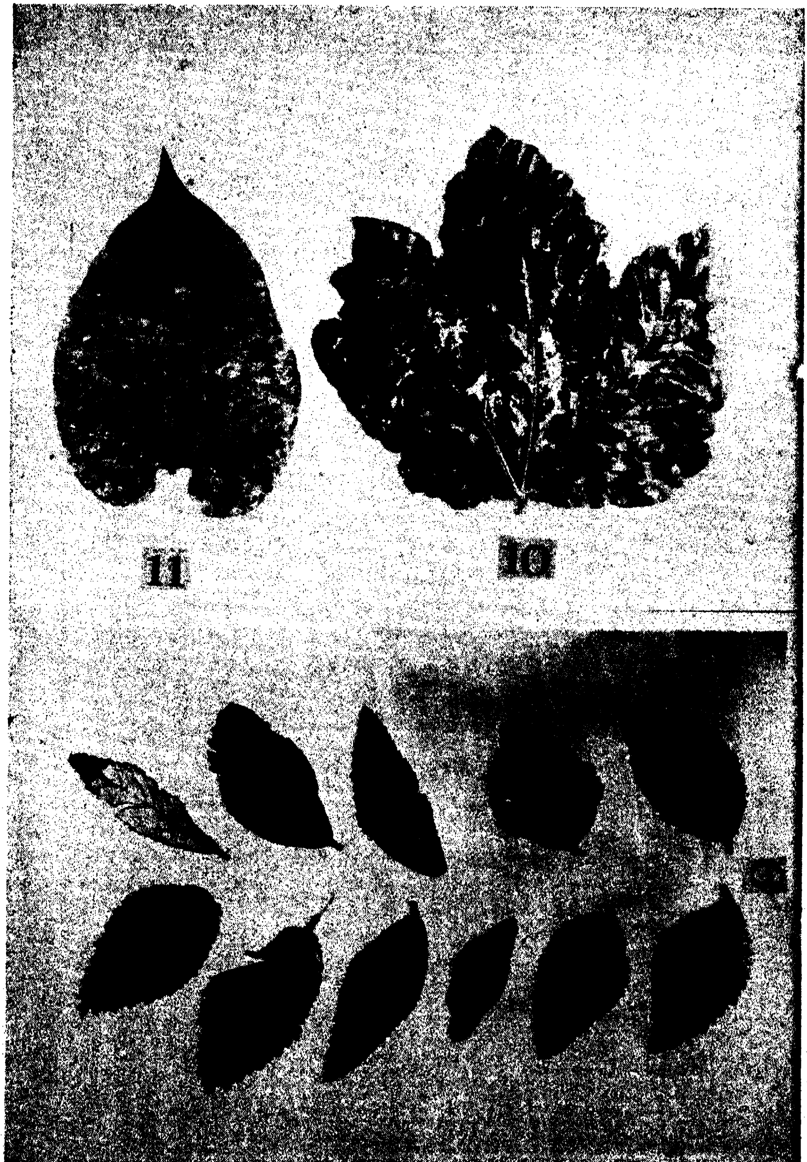


PLATE XIX.



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THE SPHAERODACTYLS OF PORTO RICO, CULEBRA AND MONA ISLANDS

CHAPMAN GRANT, MAJOR, U. S. ARMY *

INTRODUCTION

The Sphaerodactyl is little known to many collectors. He is hard to find, harder to catch and still harder to classify. That is, unless you enjoy working in the open and turning over innumerable rocks or scraping seeming acres of dead leaves. Hard to catch unless you can make up your mind to grab a fraction of a second sooner than the uncovered prize makes up his mind to dart; and he is a creature of quick decision and action. Hard to classify unless you have a large series to work with, thus avoiding the confusion of growth phases and sexual dichromatism. I know of no genus that more amply repays finding, catching and classifying than the sprightly little Sphaerodactyl.

The most valuable specific characters of these lizards at this place, using large series are:

1. Sexual dichromatism.
2. Keels or absence thereof on scales of underside.
3. Form and size of scales of snout.
4. Average adult size.
5. Color, pattern and proportions.
6. Color and pattern of newly hatched young.
7. Geographical and environmental distribution.

The male of all species has an escutcheon about five to seven scales long by ten wide, of very smooth, unkeeled scales on the lower belly, but not reaching the vent by five or six rows. It extends onto the thighs. It is obvious in even the smooth bellied species and makes sex determination easy. See Plate XX.

The egg is laid in loose dirt under or near the edge of a rock or under trash. Apparently only one is deposited at one place. The

* Major Grant has brought together a large herpetological collection while on foreign duty with the 65th Infantry in Porto Rico.

egg is nearly the size of the head so I believe a considerable time elapses between deposits. It is elliptical in outline. The shell is brittle in contrast to other lizard eggs of the vicinity. The unlaid egg can be clearly seen through the abdominal wall. The incubation period is about eight weeks.

The local name for the Sphaerodactyl is "Santa Lucia". Other names are too local to be considered.

I find no specific differences in the scale rows or labials which I have omitted in the descriptions. I have followed Barbour's "standard distance", i.e. the number of dorsal scales contained in the distance, snout to center of eye. I find the snout scales more specific and count the first row of large scales in front of eyes across snout and from this line to rostral.

Most of the species have circumscribed distribution. I believe that fortuitous distribution is exceptional. The forms are plastic and I believe that almost every island has a specific form.

I have drawn up two keys to supplement one another for the easy classification of the Porto Rican species and another one for interpolation in Dr. Thomas Barbour's key in his "Sphaerodactylus", Mem. Mus. Comp. Zoo., 1921.

It will be noted that the five new species of Sphaerodactyls herein described fall into a small subdivision of Dr. Barbour's key. This might suggest that a large series might show intergrades and that I have described variants of one or two species. I have large series and the lines of demarcation are definite and abrupt. There is no close similarity between the species and no great variation within the various species, as is more clearly shown in my keys than in the interpolation into Dr. Barbour's key. Furthermore, there is no close approximation to forms from other islands. Some writers have mistaken sexual dichromatism for variation.

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Squamation Key to the Sphaerodactyls of Porto Rico

A. Belly scales strongly keeled and pointed............*S. klauberi*
AA. Belly scales smooth and rounded.
  B. Scales on snout even in size, elongate and keeled.................................*S. macrolepis*
  BB. Scales on snout, except first two rows, elongate, even in size and keeled.
    C. Scales on head strongly keeled...*S. danforthi*
    CC. Scales on head weakly keeled ...*S. monensis*
  BBB. Scales on snout hexagonal, not elongate.
    C. Scales on snout keeled..........*S. nicholsi*
    CC. Scales on snout smooth.
      D. Scales on snout wider than long; twice as wide as those on head, uneven ....*S. townsendi*
      DD. Scales on snout hexagonal, regular..........*S. roosevelti*

Color, Size, Marking and Locality Key of Sphaerodactyls of Porto Rico

A. **Scapular pattern prominent.**
  (*a*) Scapular "mask" pattern vivid. Perfect tail tipped with white. Female with "target" head pattern; head of male plain. Sacral pattern on female only, if present, and greatly subordinated to scapular pattern. Body usually evenly spotted with brown scales in broken lines, more pronounced and larger in female. Adult average 60 mm. Not found in exceptionally dry or very humid situation. Porto Rico...*S. macrolepis*
  (*b*) Scapular "mask" pattern less pronounced. Never pronounced white tip to tail. Female more pronounced head pattern and larger body marks than in *S. macrolepis.* Males speckled or red head; not plain as in *S. macrolepis*. Under side of head except in red-head males, black and white speckled ending abruptly at throat. Adult averages 50 mm. Culebra Island..........*S. danforthi*

(c) Scapular pattern large, but dull, tending to assume "spectacle" shape. Above gray; below white. No sexual dichromatism. Rows of brown dots on back. Males have swollen heads and necks. Male escutcheon reduced in size. Adult averages 50 mm. Mona Island ---------- *S. monensis*

AA. Scapular pattern reduced or wanting.

B. Very dark brown. Seldom any scapular pattern and then merely two light dots. Underside of tail yellow or orange, seldom brown. Belly brown or lemon. Adult averages 60 mm. Found in humid mountain situations ---------- *S. klauberi*

BB. Above gray or light brown. Underside white or gray.

C. Above light gray. Females with longitudinal dark and white stripes. Belly white. Adult averages 70 mm. Head large, heavy, obtuse. Found on SW corner of Porto Rico ---------- *S. roosevelti*

CC. Brown above, belly gray. Adult averages not over 50 mm.

D. White dots of scapular pattern usually present. Sacral pattern usually very clear. Tail usually lighter color than body. Adult averages 40 mm. Found on SW corner of Porto Rico ---------- *S. nicholsi*

DD. No trace of scapular pattern. Sacral pattern usually indicated. Practically no markings. Adult average 50 mm. Found on NE corner of Porto Rico and Caja de Muertos island ---------- *S. townsendi*

KEY FOR INTERPOLATION IN "SPHAERODACTYLUS", BARBOUR, 1921, Page 226, line 14.

c 2. Dorsals keeled and larger, no differentiated mid-dorsal zone.

*   *   *   *   *   *

e 2. Five to seven scales "*1."

*   *   *   *   *   *

f 1½. Five to 5½ scales, species large (70 mm.), striped lengthwise or plain ____________________ *S. roosevelti*

f 2. More than 5 scales.

g-1. Scales of belly keeled ______ *S. klauberi*

g-2. Scales of belly and chest smooth __________________ *S. nicholsi*

g 1. Scales of chest keeled, belly smooth.

x 1. Scales on snout hexagonal and smooth _____ *S. townsendi*

x 2. Scales on snout elongate, even in size and keeled ______________ *S. macrolepis*

y 1. Scales on head strongly keeled __ *S. danforthi*

y 2. Scales on head weakly keeled ___ *S. monensis*

*1. ". . . scales" refers to the number of dorsal scales contained in length from snout to center of eye.

NOTE. A letter from Dr. Loveridge, dated April 9, 1931, in answer to my query, states that *S. notatus* has chest smooth. It is therefore not close to any of the new species described herein and does not belong where shown in Dr. Barbour's key.

Sphaerodactylus roosevelti sp. nov.

TYPE: No. 864, male. Chapman Grant Collection. Near Parguera, Porto Rico; 29 Dec., 1930; collector, Chapman Grant.

DIAGNOSIS: The largest species of the region. Marked sexual dichromatism. Gray above, white beneath. Head heavy, salamander-like. Dorsals strongly keeled, belly smooth, feebly keeled collar.

HABITAT: The extreme southwestern corner of Porto Rico where I have found it only in dry, rotten logs. Vegetation scant.

PROPORTIONS: About 10 mm. longer than *S. macrolepis or S. klauberi,* and much heavier. The head blunt, almost salamander-like. Body thick and heavy, in which it differs from all the other species of Porto Rico. About 70 mm. in length.

SQUAMATION: Scales 5 in distance from snout to center of eye.

UPPER SIDE: Scales on snout smooth, hexagonal, changing between the eyes to slightly elongate and keeled, which continue to the head, all very even in size, changing suddenly at nape to large, very pointed, keeled, imbricated scales. Scales across snout in front of eye 16. This line to snout 9.

LOWER SIDE: Scales at point of jaw large, regular, followed by smaller rounded scales which suddenly enlarge into imbricated, round scales at neck, where there is occasionally a feebly keeled collar, then large, smooth, rounded belly scales.

ORBITAL SPINE: Prominent but not as long as head scales. Gray with a black tip.

COLOR AND MARKINGS: FEMALES: Above three white stripes, beginning, one between eyes and one behind each eye. Another beginning below each eye and all extending full length of body and tail. On head, stripes bordered with black. Brown between black stripes. On body and tail alternate gray and darker stripes each about three scales wide. Below white.

MALES: Above clear gray. Beginning at neck 5 faint yellowish stripes extend length of body and onto tail. Below white.

Newly hatched young not observed.

RELATIONSHIP: This species stands alone, due to its heavy proportions and lack of color. It differs greatly from *S. macrolepis, S. vincenti* and *S. monilifer,* the only heretofore described species with keeled chest scales.

REMARKS: Specimens taken, 4. Named in honor of Theodore Roosevelt, Jr., Governor of Porto Rico.

Sphaerodactylus nicholsi sp. nov.

TYPE: No. 912, male. Chapman Grant Collection. Near Ensenada, Porto Rico, 31 Dec., 1930; collector, Chapman Grant.

DIAGNOSIS: The smallest species, averages 40 mm. Scapular pattern reduced to white dots. Scales on snout hexagonal, keeled. All underside smooth. No sexual dichromatism. Brown above with irregular lines of brown dots. "V" shaped pattern at root of tail.

HABITAT: Found in the extreme southwestern corner of Porto Rico under stones in very dry; exposed localities. Vegetation scant.

PROPORTIONS: This is the smallest of the Porto Rico Sphaerodactyls, averaging 40 mm. The general proportions are similar to *S. macrolepis.*

SQUAMATION: Scales 6 in distance snout to center of eye.

UPPER SIDE: Scales at snout large, uneven, hexagonal, keeled (except those in contact with rostral), twice the size of head scales. On head, feebly keeled, small, regular, changing abruptly at neck to large, imbricated, keeled scales with posterior margins pointed. Scales across snout in front of eye 10. This line to snout 5.

LOWER SIDE: At point of chin a group of large, hexagonal, beadlike, smooth scales, followed by very even, hexagonal small ones changing into imbricated smooth scales near neck and then suddenly into large, imbricated, smooth scales which continue several rows beyond vent, all with posterior margins rounded.

ORBITAL SPINE: About one-half the length of head scales.

COLOR AND MARKINGS: Brown above with 2 or 4 irregular broken lines of dark brown dots. Scapular pattern reduced to 2 light spots, each completely encircled by a narrow, dark ring. Sacral pattern almost always very clear, formed by 2 black lines joining at base of tail, borded on the outside by a white "V". Tail frequently yellowish. Throat clear or dotted, belly clear gray, under side of tail usually light orange, sometimes gray speckled. Newly hatched young brown above without any markings. Lighter beneath, no markings. No sexual dichromatism in this species.

RELATIONSHIP: This species is unique because of its small size. It resembles *S. townsendi* in having large, coarse scales on the snout, but they are keeled in this species.

REMARKS: Specimens taken 57. Some contained mature eggs. Named in honor of John Treadwell Nichols. The nearest approach in appearance to heretofore described species is *S. vincenti*, Barbour, 1921, Plate 9 Fig. 3, which has scales half the size of *S. nicholsi* and a keeled collar.

Sphaerodactylus danforthi sp. nov.

TYPE: No. 1725, male, Chapman Grant Collection. 16 April, 1931, Culebra Island, Porto Rico; collector, Chapman Grant.

DIAGNOSIS: Pronounced sexual dichromatism. Adult averages 50 mm. Squamation as in *S. macrolepis*. Males less marked and females more than in *S. macrolepis*. The outstanding character is

the vividly speckled throat, black and white, stopping abruptly at neck.

HABITAT: Culebra Island and Louis Pena Key, Porto Rico.

PROPORTIONS: Similar to *S. macrolepis,* but averages 50 mm. *S. macrolepis* averages 60 mm.

SQUAMATION: Similar to *S. macrolepis.*

COLOR AND MARKINGS: MALES, RED-HEAD PHASE: Top and sides of head brick red, no markings. The red fades to brown in alcohol in a few days. Back, light brown with broken lines of fine dots extending on to tail. Underside nearly white to vent. Tail tinged with yellow and speckeled with brown. 16 out of 67, or 22 per cent of the males were of this phase. These embrace males of from medium to adult size. The red head is not an exclusive adult coloration.

MALES, SPECKLED-HEAD PHASE: 49 of 65 males, or 78 per cent had heads speckled above but without target pattern. Under side of head black and white speckled, half and half, ending abruptly at throat. Rest of body as in red-head phase.

FEMALES: The 60 females have a large target pattern on head, usually a round black spot near occiput with a longitudinal black oval around it. A scapular pattern, less pronounced than in *S. macrolepis,* is followed by a series of black blotches along the back, or more frequently by five lines of large brown dots. Throat speckled as in speckled headed males. Remainder of body as in males.

YOUNG: 62 young are olive brown above with pattern clearly indicated. Lighter beneath. A trace of white tail tip and faint scapular dots which in *S. macrolepis* are decidedly white.

RELATIONSHIP: In general proportions this species is closest to *S. macrolepis* from which it differs in smaller size; coarser, darker pattern; males of two color phases; the greater degree of sexual dichromatism and the usually vividly speckled throat with the speckling stopping abruptly at neck. It differs greatly from *S. vincenti* and *S. monilifer,* the only other heretofore described species with keeled collar.

REMARKS: Barbour, "Sphaerodactylus", 1921, Plate 6, Fig. 2 shows a good representation of a female *S. danforthi.* His Fig. 3 resembles a female *S. macrolepis.* I gathered about 30 eggs in loose dirt under heaps of dead vegetation. The incubation period is about 8 weeks. The young are very active. Specimens taken 157. I believe that further study will show that two species are included in the above, as the red head males have larger scales than the others

and there are large scaled females, but I have not as yet definitely separated them. The *Sphaerodactyl* on Culebrita Island does not agree with those described above. A large series may prove of interest. Named in honor of Dr. Stuart T. Danforth.

Sphaerodactylus klauberi sp. nov.

TYPE: No. 975, Male. Chapman Grant Collection. 11 Jan. 1931, El Yunque, Porto Rico; collector, Chapman Grant.

DIAGNOSIS: The only species in this region with keeled belly scales. Very dark brown above. Below dark brown or some shade of orange or yellow.

HABITAT: This species is found in the moist canyons of the higher mountains where the ground is saturated. It hides under stones or logs or is found within rotten logs.

PROPORTIONS: Similar in size and proportions to *S. macrolepis,* from which it differs in keeled belly scales and color.

SQUAMATION: Scales 6 in distance snout to center of eye.

UPPER SIDE: Scales at snout larger than on head, all pointed, elongated, keeled (except those bordering rostral), gradually enlarging at nape to the larger dorsals. Scales across snout in front of eyes 14, this line to snout 6.

LOWER SIDE: At point of chin, group of larger, even elongate, pointed, keeled (except those touching mental) scales, followed by similar smaller ones which gradually become larger towards belly. All elongated, keeled, imbricated and pointed, continuing for 5 or 6 scales below base of tail.

ORBITAL SPINE: One-half length of head scales. Not much larger than preceding prominent scales.

COLOR AND MARKINGS: Almost black above. Scapular pattern, if present, rudimentary and not obscured by dark back but reduced to two light, not white, dots. Under side dark, frequently tinted with a shade of lemon or orange. Under side of tail usually a deep orange but sometimes brown. Newly hatched young not observed. No sexual dichromatism in this species.

RELATIONSHIP: In general proportions this species is closest to *S. macrolepis,* from which it is easily distinguished by its keeled belly scales, absence of a distinct scapular pattern and by its very dark color.

REMARKS: Specimens taken 24. Differs widely from *S. goniorhynchus, S. fantasticus* and *S. microlepis,* the only other species with keeled bellies. Named in honor of Laurence M. Klauber.

Sphaerodactylus townsendi sp. nov.

TYPE: No. 1080, female. Chapman Grant Collection. 25 Jan., 1931, Cape San Juan, Porto Rico; collector, Chapman Grant.

DIAGNOSIS: No trace of scapular pattern. Sacral pattern usually indicated. Practically no markings. Average adult 50 mm. Scales on snout hexagonal, smooth, wider than long, uneven.

HABITAT: The promontories that jut out at the northeast extremity of Porto Rico and Caja de Muertos island. Vegetation, scant grass and cactus.

PROPORTIONS: Between the heavy *S. roosevelti* and the slender *S. macrolepis*. General proportions closest to *S. monensis* from which it differs in squamation and pattern.

SQUAMATION: Scales 6 in distance snout to center of eye.

UPPER SIDE: Scales at snout very large, uneven, smooth, hexagonal, wider than long, twice the diameter of those on head. On head, small, regular, elongated, keeled, gradually changing at neck to large, imbricated, keeled, pointed scales. Scales across snout in front of eyes 10. This line to snout 5.

LOWER SIDE: Scales at point of chin large, hexagonal, smooth, bead-like, followed by very even, hexagonal small ones, changing into imbricated scales near neck where there is occasionally a collar of feebly keeled scales, suddenly changing into large, imbricated, smooth scales which continue several rows below the vent. All imbricated scales with posterior margins rounded.

ORBITAL SPINE: Small, shorter than head scales, but prominent, since not preceded by large scales.

COLOR AND MARKINGS: Upper surface brown, lead gray in alcohol. Head minutely speckled but without pattern. No scapular pattern. Back uniform, or with a few broken rows of brown dots, frequently becoming distinct in the sacral region and joining at the base of the tail, forming a sacral pattern. Frequently a faint light line from the eye to the pelvis making the sacral pattern more distinct. Tail frequently with faint tinge of yellow. Chin faintly speckled, belly light gray or with a suggestion of orange. Newly hatched young solid brown above, lighter beneath. No sexual dichromatism in this species.

RELATIONSHIP: Closest to *S. monensis* from which it is clearly distinguishable by pattern and squamation. Differs greatly from the other keeled collar species.

Seventeen specimens from Caja de Muertos island averaged lighter underneath and fewer markings above. A large series may prove it to be a sub species.

REMARKS: Specimens taken 340. Named in honor of Charles Haskins Townsend.

Sphaerodactylus macrolepis Gunther

Synonymy omitted

DIAGNOSIS: Scales above strongly keeled; on snout, elongate, even, keeled. Below, smooth except for keeled collar. Scapular pattern vivid. Tail tipped with white. Sexual dichromatism. Average adult 60 mm.

HABITAT: Distributed in foci throughout Porto Rico except in localities of extreme drought or moisture. It is found under stones or piles of rubbish.

PROPORTIONS: Head small and pointed. Tail equal to length of head and body. Slender. About 60 mm. in length.

SQUAMATION: Scales 5 or 6 in distance, snout to center of eye.

UPPER SIDE: Scales at snout even, keeled (except those bordering rostral), elongate similar in shape and size to those on top of head which change suddenly at nape to the pointed, keeled, imbricated dorsals. Scales across snout in front of eyes 16, this line to snout, 7.

LOWER SIDE: At chin, a group of large, elongated scales followed by smaller ones, all feebly keeled to neck, where a collar of rounded keeled scales is followed by smooth, rounded belly scales.

ORBITAL SPINE: As long as head scale. Preceded by one or two prominent scales.

COLOR AND MARKINGS: Varies slightly, but is best known by its scapular pattern of a black blotch containing two livid white spots. Resembles a black mask. Back brown with six broken lines of dark brown scales to the tail, where they usually continue as irregular dark spots. The tip of a perfect tail is white, sometimes preceded by a black ring, but this marking is never regenerated and hence is rarely found in adults. Throat clear or dotted. Belly clear gray or yellowish. Underside of tail gray, brown or some shade of orange.

NEWLY HATCHED YOUNG: Black above, lighter beneath, with tip of tail white and two scapular white dots.

SEXUAL DICHROMATISM: Males: Head above, clear brown or finely speckled. Very rarely a faint trace of pattern. Spots on body smaller than on female. No sacral pattern. Speckled chin more frequent than in female.

FEMALES: Pronounced target pattern of a black spot near occiput surrounded by a longitudinal black oval. Rarely a female is seen without head pattern. Spots on body larger than on male. Some have sacral pattern. A few have finely speckled chins.

The dichromatism is not as pronounced as in *S. roosevelti* or *S. danforthi*. There is only a small percertage however, that might confuse a person unused to handling the species. After a short acquaintance the division into sexes can readily be made by color pattern without checking on the male escutcheon, which is, of course, clear and definite.

RELATIONSHIP: In general proportions this species is closest to *S. klauberi* and *S. danforthi*. The keeled belly scales and dark color of the former and the smaller size and different markings of the latter, make it very distinct.

REMARKS: Specimens taken 140. This species is best described and figured by Stejneger, 1904, Figs. 46–50. Schmidt, 1928 shows a female in his Fig. 26 A and a male in Fig. 26 B. He did not note the significance of the markings, attributing it to variation. Barbour, 1921, shows a female in Plate 6 Fig. 3. Fig. 2 resembles a female *S. danforthi*. Stejneger, 1904 shows a male in Fig. 51 and a female in Fig. 52. On Page 605 we find: "In the specimens collected in the white clay hills about three miles east of Ponce on April 16 (Nos. 27306–12) two similar types of coloration are also easily distinguishable, namely, those with uniform yellow heads without dusky markings but with the tail spotted like the back, and those with an unspotted ochraceous tail but a drab-colored head with a pattern, like Fig. 52, and longitudinal dusky marks on the back." Stejneger did not note that the two types of coloration corresponded with the sexes.

I believe that the above form is really *S. grandisquamis*, Stejneger, 1904, and that *S. macrolepis* is confined to St. Thomas and possibly other Islands. I hope to be able to prove this at a later date.

Sphaerodactylus monensis (Meerwarth)

1901 *Sphaeradactylus macrolepis a monensis* Meerwarth, Mitth. Naturh. Mus. Hamburg, XVIII, p. 20. Type locality, Mona Island; types, Hamburg Mus., Nos. 1207 a–b.

1904 *Sphaerodactylus monensis* (Meerwarth) Stejneger, U. S. Nat. Mus. p. 607.

1921 *Sphaerodactylus macrolepis* Gunther, Barbour, Mem. Mus. Comp. Zoo. p. 253.

1928 *Sphaerodactylus macrolepis* Gunther, Schmidt, N. Y. Acad. of Sci. Vol. X. Part I., p. 70–74.

1930 *Sphaerodactylus macrolepis* Gunther, Barbour. Zoologica, Vol. XI No. 4.

DIAGNOSIS: Medium size, 50 mm. Back gray, belly white. Scapular pattern distinct but pale. Sacral pattern crescent shaped. Belly smooth, chest feebly keeled. Male escutcheon much reduced. No sexual dichromatism. All scales on upper side of head are feebly keeled except for a patch between eyes which is strongly keeled.

HABITAT: Mona Island, Porto Rico.

PROPORTIONS: Similar to *S. townsendi* except large males have distended cheeks and necks. Differs in pattern and squamation.

SQUAMATION: More feebly keeled throughout than any other species in this region. Belly smooth, chest feebly keeled. Male escutcheon much reduced. First two rows of scales on snout hexagonal, smooth, wide, followed by elongated, keeled scales between eyes, followed by small, bead-like, feebly keeled scales on head which change abruptly at nape (beginning of scapular pattern) to pointed, imbricated, keeled dorsals. First row of large scales across snout in front of eyes averages 11½, this line to snout averages 4½.

ORBITAL SPINE: Short. Followed by one or two enlarged scales.

COLOR AND MARKINGS: Gray above; white beneath. Head pattern very faint olive markings on tan background. Dusky line forward from eye. Broken lines of brown scales on back. Scapular pattern with a distinct tendency to "spectacle shape" with neither the white nor black distinct; a very subdued pattern. Sacral pattern present, in form of a transverse crescent, points forward, dark line anteriorly bordered by light line posteriorly. More prominent than in any species of this region. Throat not dotted. No yellow under side of tail, except in specimens shrivelled in alcohol which turns many specimens brown. No sexual dichromatism. No young or eggs observed.

RELATIONSHIP: Unique in markings and keeling. Large males have the swollen neck shown by Barbour, 1921, Pl. 6, Fig. 1, *S. gilvitorques* Cope. It has no other similarity however. It differs from *S. macrolepis* in not having sexual dichromatism and in markings and color and specially in squamation of head which does not approximate *S. macrolepis*. It differs from *S. townsendi* in squamation and pattern. It is not close to any other species of this region. In a series it is unlikely to be confused with any other form.

REMARKS: Specimens taken, 51. This species is found under trash or objects on the ground. It is extremely active. I believe there may be two species on Mona Island.

EXPLANATION OF PLATES XX–XXIV

Fig. 1. *Sphaerodactylus klauberi*, sp. nov.
Ventral aspect of male to illustrate escutcheon.
The escutcheon is found only on the males and makes sex determination easy. Note shape and position. The keeled belly scales of this unique species makes the escutcheon very prominent, but it is discernible in all species. This figure also illustrates the patch of fine scales in front of the hind leg. There is another patch behind the front leg. Common to all species.
6 × natural size.

Fig. 2. *Sphaerodactylus macrolepis* Gunther. Female. Note "target" pattern on head and prominent scapular "mask" pattern; coarse dots on dorsum and indication of sacral pattern.

Fig. 3. Same species. Male. Note plain head, lack of sacral pattern and finer dots on dorsum than on female.

Fig. 4. *Sphaerodactylus roosevelti* sp. nov. Female. Note shape of head and vivid unique markings.

Fig. 5. Same species. Male. No markings.

Figs. 2–5 all $1\frac{1}{3}$ × natural size.

Fig. 6. *Sphaerodactylus danforthi* sp. nov. Underside of speckle-head male. Note prominent escutcheon scales on this smooth-bellied species. Note speckled throat and immaculate belly which are the same in female.

Fig. 7. Same species. Female. Note "target" pattern on head and coarse black spots on dorsum. Underside same as Fig. 6 except that there is no escutcheon on female.

Fig. 8. Same species. Male. Speckle-head phase. Note fine speckles and absence of head pattern; dorsal dots finer than on female.

Fig. 9. Same species. Red-head male. Note plain head, speckled back and absence of pattern.

Fig. 10. Same species. Red-head male. Underside. Note plain chin. The escutcheon can be plainly seen. Note larger scales on Figs. 9 and 10. This may prove to be a separate species, but to date I am unable to distiguish between the females.

Figs. 6–10 all $1\frac{3}{4}$ × natural size.

Fig. 11. *Sphaerodactylus nicholsi* sp. nov. Note comparative size; no head pattern; scapular pattern reduced, but sacral pattern prominent. No sexual dichromatism.

Fig. 12. *Sphaerodactylus townsendi* sp. nov. Note comparative size and absence of all save sacral pattern. No sexual dichromatism.

Fig. 13. *Sphaerodactylus klauberi* sp. nov. Note comparative size, dark color and absence of markings. No sexual dichromatism.

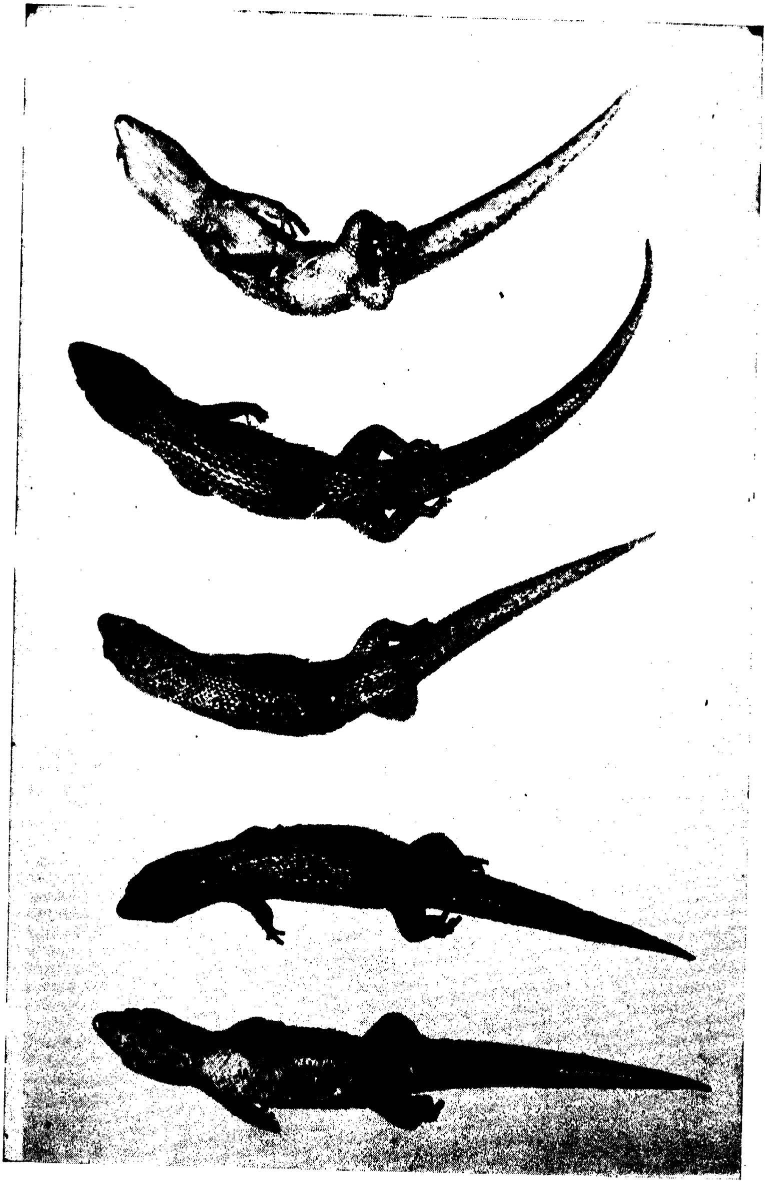
Figs. 11–13 all $1\frac{7}{8}$ × natural size. Specimens are average.

PLATE XX.

PLATE XXI.

2 3 4 5

PLATE XXII.



6 7 8 9 10

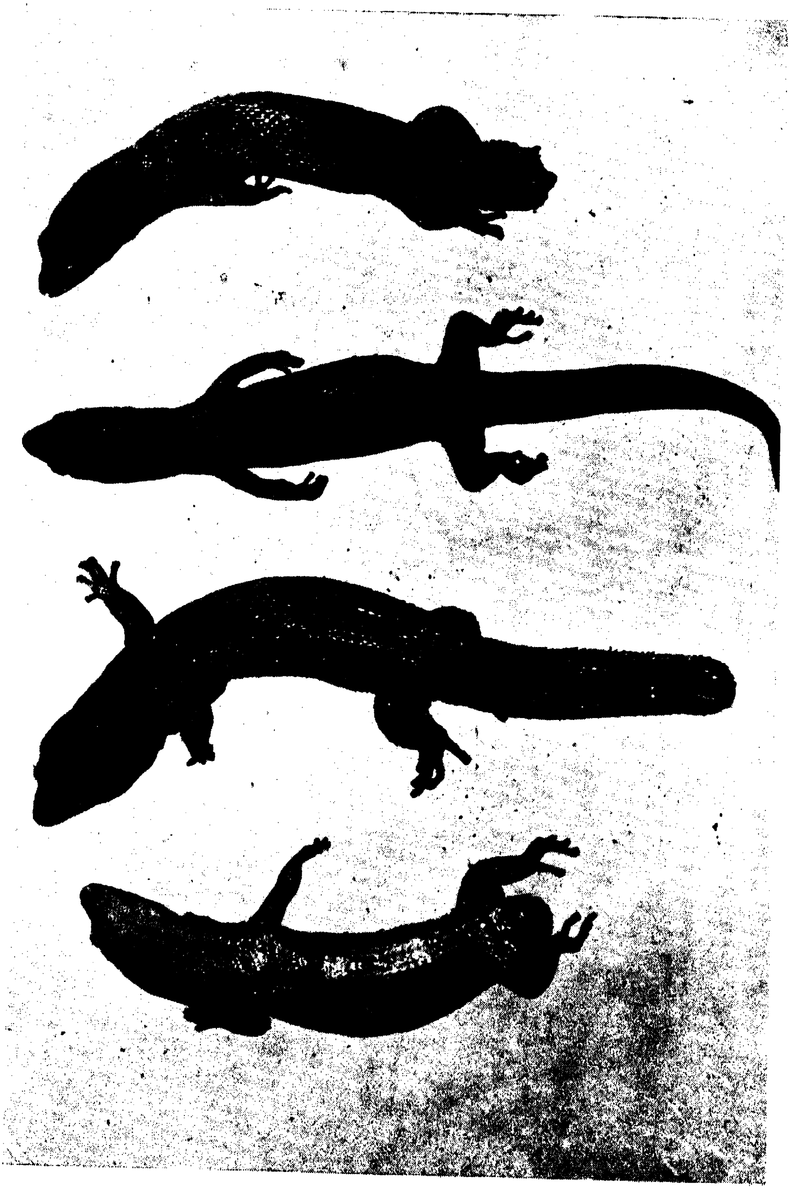
PLATE XXIII.

13

12

11

PLATE XXIV.



14 15 16 17

Fig. 14. *Sphaerodactylus monensis* (Meerwarth) Male. Note greatly reduced escutcheon and pure white color. Both sexes are white underneath.

Fig. 15. Same species. Male. Showing greatly enlarged head and neck. Note scapular pattern is not vivid and is in form of "spectacles".

Figs. 16–17. Same species. Females. Note no sexual dichromatism. Note sacral pattern peculiar to this species.

Figs. 14–17 all $2\frac{1}{2} \times$ natural size.

A REVISED LIST OF THE HERPETOLOGICAL FAUNA OF CULEBRA ISLAND

Chapman Grant, Major, U. S. Army

Schmidt, 1928 gives the following nine amphibians and reptiles as comprising the Culebra Island herpetological fauna. After each name is added the number of specimens collected on the present trip.

1. *Leptodactylus albilabris* (Gunther)	4
2. *Eleutherodactylus antillensis* (R. & L.)	1
3. *Anolis cristatellus* (see below)	0
4. *Anolis stratulus* Cope	16
5. *Anolis pulchellus* (D. & B.)	23
6. *Amieva exsul* Cope	20
7. *Mabuya sloanii* (see below)	0
8. *Dromicus exiguus* Cope	0
9. *Alsophis antillensis* (Schlegel)	28

The following species were taken and are added to the above list:

1. *Sphaerodactylus danforthi* sp. nov. 1*	180
2. *Anolis roosevelti* sp. nov. 2*	1
3. *Typhlops jamaicensis* (Shaw)	10

Of the original list I have changed the following:

1. *Mabuya sloanii* (Daudin) to *M. semitaeniatus* (Wiegmann) 3*	27
2. *Anolis cristatellus* D. & B. to *Anolis cristatellus wileyi* sub sp. nov. 4*	41

This makes a total of 12 species now known to inhabit Culebra Island.

At the time of my visit, April 15–24, 1931, the island was extremely dry which accounts for the poor showing of *Salentia* and probably for the lack of *Dromicus exiguus* Cope which may have been aestivating.

I found *Anolis cristatellus wileyi* the only common reptile with *Sphaerodactylus danforthi* next in number. *Amieva exsul* was not common on Culebra, not seen on Louis Pena key, but was the most abundant form on Culebrita. *Anolis pulchellus* (D. & B.), *Anolis stratulus* Cope and *Amieva exsul* Cope showed no variation from their Porto Rican relatives.

1*, 2*, 3* and 4* described on pages 205, 219, 217 and 220 respectively in this number.

REESTABLISHMENT OF A SCINCID LOST SINCE 1837

CHAPMAN GRANT, MAJOR, U. S. ARMY

Mabuya semitaeniatus (Wiegmann)

Euprepes semitaeniatus, Wiegmann, Arch. f. Nat. p. 135______ 1837
Mabuya sloanii (Daudin) Stejneger, Report U. S. Nat. Mus. for 1902 p. 610______ 1904
Mabuya sloanii (Daudin) Schmidt, N. Y. Acad. Sci. Vol. 10, Pt. 1, p. 121______ 1928
Mabuya sloanii (Daudin) Barbour, Zoologica, p. 105______ 1930
The type is No. 5290 in the Berlin Nat. Hist. Museum.

Wiegmann described *Euprepes* (*Mabuya*) *semitaeniatus* in 1837 from an unknown source. Since that time the few specimens obtained have been grouped with *M. sloanii* (Daudin) as synonymous. The difference in coloration was noted by Stejneger and Schmidt, but sufficient material was not at hand to prove the specific differences.

My collection contains six *Mabuyas* from Porto Rico which agree with Schmidt, 1928 Fig. 38 A in color and pattern. Counting his specimens this makes 8 from Porto Rico which are clearly *M. sloanii*.

I have just taken a series of 27 specimens from Culebra Island and the adjoining SW key, known as Louis Pena Key, and 35 from Mona Island. All agree exactly in color and pattern with Schmidt, 1928, Fig. 38 B in having the narrow median light line. This brings the total to 62 which agree in coloration.

My Porto Rico specimens have the back a uniform brown. Most of those from Culebra and Mona islands have a series of marks consisting of the center third segment of the scale being almost black. These marked scales spread from the lateral and dorsal dark bands, forming broken lines of triangular dots, more or less numerous along the back and clear down the tail in some specimens. The median line on the head is as light as the white dorso-lateral line in some from Mona and Culebra islands, but much darker in those from Porto Rico. The dorso-lateral light lines on the Porto Rico specimens are irridescent bluish along the body, whereas they are cream colored in the Culebra and Mona islands specimens.

I kept one female alive and she bore four young in from 36 to 48 hours between the first and last. The mother and young take insects, crickets, cockroaches and sowbugs. The young are colored like the adult except the tail which is white at the tip and lavendar nearly

to the body. This is reminiscent of the "blue tailed" skink of the middle west United States, *Eumeces guttulatus,* which it remained for Burt, 1928 to show was the young of *E. obsoletus* (B. & G.)

On Culebra and Mona islands the *Mabuya* or "Lucia" as the natives call it, is found among *Opuntia repens* Bello, at sea level just above the beaches and among the rocks on the hills. Some inhabit houses. They are tame, but show strength when held in the fingers. They make no attempt to bite.

In discussing *M. spilonota,* Wiegmann, from Jamaica and *M. sloanii* (Daudin); Stejneger 1904. p. 609, states: "Thus, separated supranasals and three pairs of nuchals seem to predominate in *M. spilonota,* while supranasals in contact and two nuchals belong to the eastern form". (*M. sloanii* and *M. semitaeniatus.*) These observations are borne out by my series of which 43 have the supranasals in contact and 18 only have them separated. Of nuchals, 2 have 1–1; 15 have 2–1; 31 have 2–2; 9 have 2–3; 2 have 3–3; 1 has 1–6 and two are mangled.

I notice that most specimens, and especially the young, have a pronounced transluscent pineal spot, sometimes pit, at the posterior part of the interparietal scale. One freak specimen has two small scales at this point which resemble occipitals.

The separation of *M. semitaeniatus* from *M. sloanii* rests on the constant color and pattern difference. The specimens in my collection I believe reestablish the name *Mabuya semitaeniatus* (Wiegmann) for the Culebra and Mona island species.

Photograph by Captain Frederick V. Edgerton, U. S. A.

Explanation of Plate XXV

Mabuya semitaeniatus Wiegmann.
Note head pattern.
Four young were born in captivity. Their tails are lavendar with white tips.
1⅓ × natural size.
Photo by Capt. Frederick V. Edgerton, U. S. A.

PLATE XXV.

A NEW SPECIES AND TWO NEW SUB-SPECIES OF THE GENUS ANOLIS

CHAPMAN GRANT, MAJOR U. S. ARMY

Anolis roosevelti sp. nov.

TYPE: No. 1884, male, Chapman Grant Collection, Culebra Island, Porto Rico, 22 April, 1931; collector, Chapman Grant.

DIAGNOSIS: A giant *Anolis* of the *A. cuvieri* type. Top of head deeply grooved. Ear opening triangular. Lower loreal row small. Head more pointed than in *A. cuvieri* viewed both from side and above.

HABITAT: Culebra island.

PROPORTIONS: Similar to *A. cuvieri* except head which is more slender and pointed. Larger than any specimen of *A. cuvieri* of which I can find any record.

DESCRIPTION:	*A. cuvieri*	*A. roosevelti*
Top of head	flat	deeply grooved.
occipital	barely noticeable	fairly prominent
lower loreal row	largest	small
ear opening	small, oval	large, triangular
dorsal ridge	50 spines	70 small spines
scales on chin	keeled	not keeled
rows between rays	3 to 4	5
loreal surface	vertical	sloping
Measurements of Sschmidt's "largest specimen", 1928.		
length of head	43 mm	56
breadth of head	26	33
arm	60	91
leg	100	142
body	135	160

A further difference is that if the loreal ridge were projected to intersect the line of the cutting edge of the upper jaw they would intersect in *A. cuvieri* beyond the end of snout and in *A. roosevelti* at end of snout.

The supraocular semicircles leave a deep groove from the occiput

of the males are uncommon on Porto Rico, but predominate on the keys just east of Porto Rico and on Mona Island.

Anolis cristatellus wileyi subsp. nov.

HABITAT: Culebra Island and adjoining keys.

TYPE: No. 1885, Chapman Grant Collection, Culebra Is., P. R. collector, Chapman Grant. 15 April 1931.

DIAGNOSIS: Similar to *Anolis cristatellus cristatellus* except that the throat fan of the male has an edging of not less than one-half the radius of very deep orange. The females have the entire patch deep orange. This is constant.

During a ten day collecting trip I preserved 41 specimens, handled many more and observed hundreds of *Anolis cristatellus wileyi.* There was no exception to the wide, deep orange edge of the fan. The difference between this and the Porto Rican species is striking. High tail fins are more numerous than on Porto Rico. A preserved specimen resembles *Anolis cristatellus cristatellus.*

Named in honor of Grace Olive Wiley.

Anolis cristatellus cooki subsp. nov.

HABITAT: Brea Point, S. W. Porto Rico.

TYPE: No. 780. Chapman Grant Collection, Brea Point, P. R., collector, Chapman Grant. 28 Dec., 1930.

DIAGNOSIS: Similar to *Anolis cristatellus cristatellus* except that the entire throat fan is chocolate color, and a light line beginning on the upper labials extends above the front leg, thence diagonally down to the groin.

The southern side of Punta Brea, SW of Guanica is desert-like. A few shrubs and cactus grow among coral slabs. In an area 100 by 500 yards in extent I found a few small, slender *cristatellus* with uniform chocolate colored fans. The body color was nearly white. I attach no significance to the white color or the small size, since I took only five specimens. There were no intermediate forms and no specimens inhabited the area between this little colony and the north side of the point where the bull headed, orange and green fan *Anolis cristatellus cristatellus* was found. In alcohol these specimens remain lighter than the Porto Rico form, but the peculiarity of the fan is lost to a great extent.

Named in honor of Dr. Melville T. Cook.

This little colony forms a link between *Anolis cristatellus cristatellus,* D. & B. and *Anolis monensis* Stejneger. It resembles the

to near the snout. At center of ridges, groove is half as deep as wide. The canthus rostralis and semicircle have a groove between them half way to snout. Two median ridges from line with fore part of orbits to near snout inclose a deep groove and form two lesser grooves with the projection of supraocular semicircles. Thus at level with fore part of orbits there are five distinct grooves.

Fin on tail very high. Third from distil ray twice as long as depth of tail. The fourth proximal ray as long as depth of tail.

Scales on side of tail larger than in *A. cuvieri* which in turn are larger than in *A. ricordii.*

At 5th ray from base of tail:	*A. cuvieri*	*A. ricordi*	*A. roosevelti*
longitudinal rows	10–14	16–20	10
vertical rows	3–4	5–6	5

A comparison with Stejneger's 1904 Figs. 85–86 shows that *A. roosevelti* differs from *A. ricordii* greatly in the grooves on the head.

COLOR: Living specimen; brownish gray with two light lines on each side. One from ear to groin, the other from shoulder to groin. A distinct light spot on temple. Eyelids yellow. Fan gray except lower rear quarter which is light yellow. Tail yellowish brown. Underside whitish.

Named in honor of Theodore Roosevelt Jr., Governor of Porto Rico.

One specimen taken.

TWO NEW SUB-SPECIES OF ANOLIS CRISTATELLUS

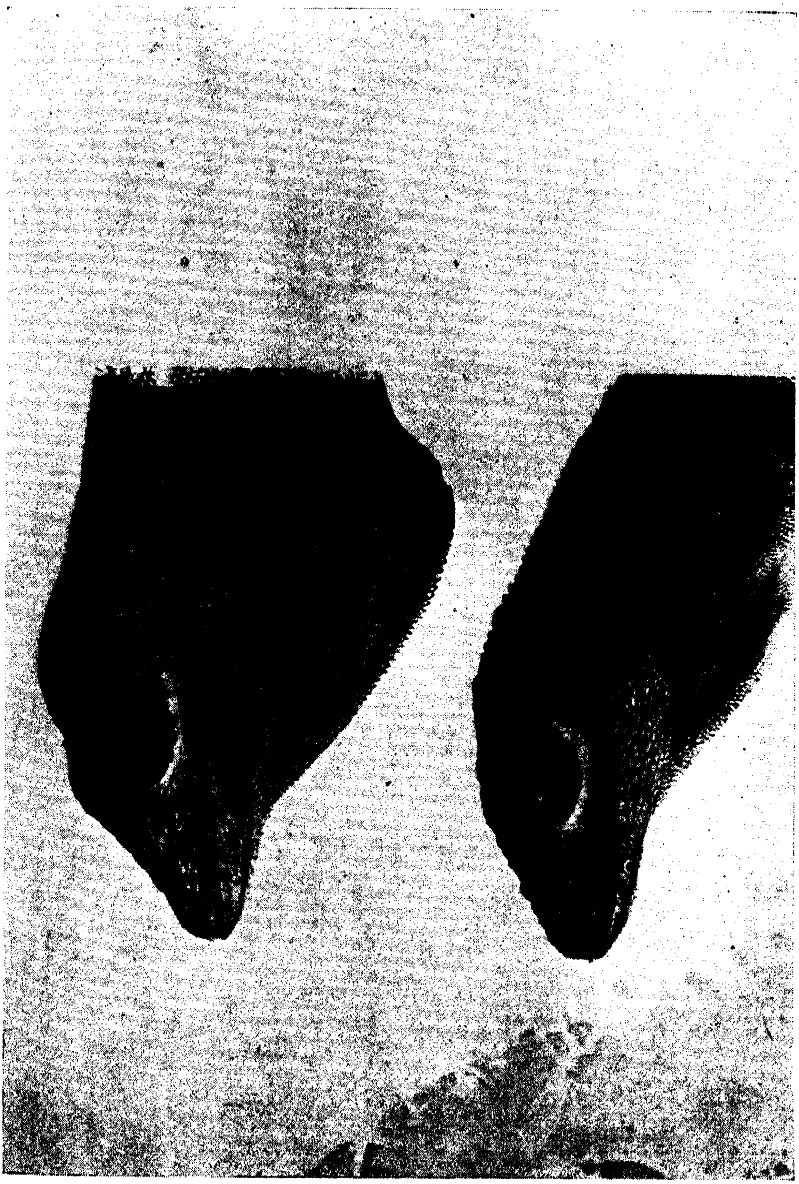
Anolis cristatellus cristatellus Dumeril and Bibron, on Porto Rico runs the gamut of all the color changes and patterns known or imagined. After eight months of intimate contact with them, during which time I have preserved well over 300, picked up and handled many more and watched literally thousands, I still occasionally see a pattern or color combination new to me. The females are the ones that show the most marked diversity. One thing, however, I consider of sub-specific value. That is the colors of the throat fan. Unfortunately these do not last well in alcohol. The colors fade and the fan becomes stiff and shriveled. On Porto Rico the fan varies from a uniform light olive green throughout to a light green center edged with orange. The orange edge seldom equalling one half the radius of the fan and usually only a narrow edging. In some cases the light orange extends up on the sides of the neck. High tail fins

latter in having the oblique lateral light line and in having the fan a uniform color, but lacks the specific transocular dusky line. I have noted in handling many fresh or living *Anolis monensis* that the fan is almost invariably of one color—orange yellow. Occasionally one is seen with a suggestion of green in the center of the fan and occasionally an orange fan is seen, but never the deep orange of the Porto Rico form (*A. c. c.*) At Playa Sardinera on Mona Island I have seen specimens with a lavendar metallic luster on the head and on the tail fin. The belly of *Anolis monensis* averages much brighter deeper yellow than the other forms. Stejneger, 1904, p. 646 in describing *Anolis monensis* says: "... a distinct transocular, dusky line. In many specimens there is a distinct white line from shoulder to groin. The color of the dewlap can not be made out in alcoholic specimens, but there are indications that it is different from that of *Anolis cristatellus.*" This description was based on 14 specimens. It is fully supported by the 185 specimens in my collection. Barbour, 1930 admits the validity of *Anolis monensis.* Schmidt, 1928 considered it synonymous with *Anolis cristatellus cristatellus.*

Explanation of Plates XXVI–XXVII

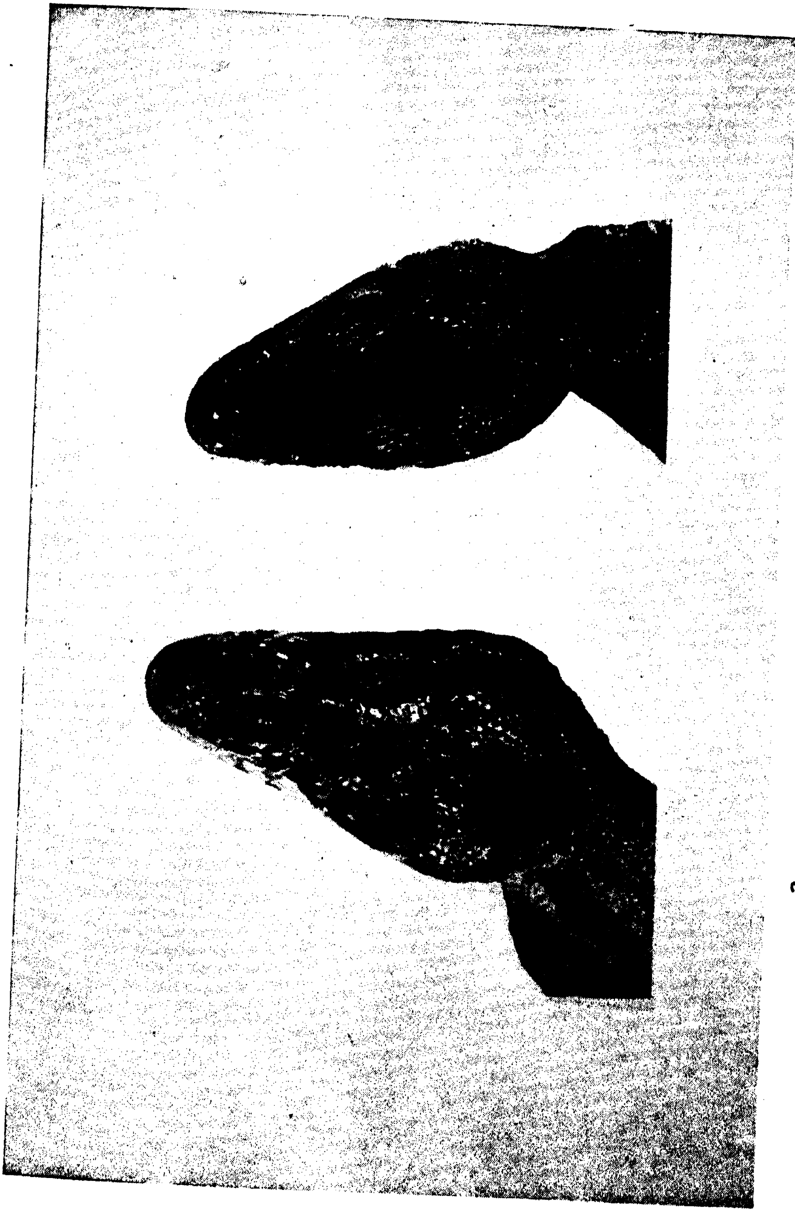
Fig. 1. *Anolis roosevelti* sp. nov. Note pointed snout and high occipital region.
Fig. 2. *Anolis cuvieri* Merrem. Note blunt snout and low head.
Figs. 1 and 2. Life size.
Fig. 3. *Anolis roosevelti* sp. nov. Note deep grooves on head; prominent occipital; pointed snout.
Fig. 4. *Anolis cuvieri* Merrem. Note flat head; absence of visible occipital scale.
Figs. 3 and 4. 1¼ × natural size.

PLATE XXVI.



1 2

PLATE XXVII.



4

3

STUDIES ON CACAO

I. ACTINOMYCETES ON CACAO BEANS

R. CIFERRI, Santiago, Dominican Republic.

A paper on Actinomycetes or ray-fungi which causes the "mould odor" or "ground odor", or, according to Fellers (**11**), "Actinomyces odor" on dry cacao beans was published in the German Language (**2**), and later new observations were published in the Italian language (**3**). These two papers will be briefly summarized at this time in order to make this series of studies more complete.

In spite of the fact that arthrospores, or true spores, or fragments of the mycelium of Actinomycetes are normally present on dry fermented and unfermented cacao beans, the peculiar taste is not perceptible until the full development of the ray-fungi, e. g., after 52–76 hours of incubation in moist environment. The presence of the microorganisms may be revealed also by the presence of a superficial white dust. Its development is active at 20–25° C., maximum from about 30° C. to 40° C., but in the last case, the taste is mixed musty and rancid, in the other being from musty to musty-ground. Cultures from washing water of cacao seeds in carrot agar and in Czapek-Waksman agar revealed from 1110 to 3760 Actinomycetes for each gram of cacao beans, with an average of 2063 Actinomycetes on eight determinations.

The species most frequently isolated is the *Actinomyces albus* Krainsky emend. Waksman and Curtis, according the description of Waksman (**28**), in a slightly distinct variety (var. *alpha* Cif.). *Actinomyces griseus* Kr. and three other not identified species or forms were present, but scarcer.

In the opinion of the writer, this microorganism is passively carried from the soil to the shell of the cacao pod by the winds and the rainfall. Washing the bark of healthy pods the writer obtained from 36 to 408 colonies of Actinomycetes per gram of fresh pod, with an average of 195 colonies (six determinations). From the air of a cacao estate Actinomycetes were present in the proportions of 3, 9, 8, and 14 per cent of the colonies developed. But the most active agents for carrying spores of Actinomycetes are the men who break the shells of the cacao pods, extracting the masses of cacao beans and isolate the seeds from the rachis. If the beans are fermented, another source

of contamination is the fermenting boxes, from which Actinomycetes were isolated. The Actinomycetes are diffused also by the fermentation liquor, containing from 5 to 11 ray-fungi for each gram of the liquor, with an average of 7 from four determinations. The fermentation humour was inoculated until 4906 colonies of *Actinomyces albus* were obtained for each c. c.; samples were taken each three days and the colonies enumerated. On the 15th day the number decreased to 3550. The conclusion was that the *Actinomyces* live but in an inactive form in the fermentation liquor. The same humour, freshly taken from the fermentation boxes, sterilized and inoculated with 13780 germs per c. c. at the 15th day contained 14070 ray-fungi per c. c.

Previously the writer (**4**) studied the mouldy taste of the wine, finding that the ray-fungi are living on rotten wood of the casks and tuns (less well on unaltered wood), and may communicate easily to the wine the peculiar taste *. According to Fellers (**11**), the bitter taste and the Actinomyces odor of the milk is caused by the *Actinomyces griseus* Kr. Zedfield attributed the same taste of the eggs to the ray-fungi. The mouldy taste of Javanese tobacco sent from Java to Europe in good condition, according to Gandrup (**13**) is caused by unidentified species of Actinomycetes.

The complete prevention of the contamination of cacao beans is impossible, from the practical standpoint, but may be reduced to a minimum by: (1) avoiding the contamination by soil; (2) isolating rotten or wounded pods, chiefly the pods damaged by the bird (*Picumnus* [*Centurus*] *striatus*) and by fruit-eating bats, from healthy pods; (3) avoiding the introduction in the mass of cacao beans of leaves, small branches, and portions of shell of the cacao tree or pod; (4) rigorous cleaning and disinfection of the fermentation boxes; (5) avoiding the mixture of cacao beans from rotten or wounded pods with beans from healthy cacao pods.

Also it may be noted that unfermented cacao beans are poorer in Actinomycetes than the fermented ones (from 320 to 1230 colonies for each c. c. of washing water, with an average of 776 per c. c., as obtained from six determinations), and, of course, unfermented cacao is less susceptible to the mouldy taste than the fermented.

From the technologic standpoint, this moulding is of course, very distinct from the true moulding, but of a very reduced importance, as the contamination is limited to the external surface of the cacao

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* The Actinomycetes causing the mouldy taste of the wine was identified as the *Streptothryx Sanninii* Cif., but according to the most accepted generic nomenclature, it is a species of *Actinomyces* and very similar to *A. albus*.

beans. From the commercial standpoint, it may be observed that the responsibility of the farmer is very limited, and the growth in number of the Actinomycetes, as well as the development from the arthrospores or resting spores being effected during shipment.

II. FUNGOUS FLORA OF DRY CACAO BEANS

Two types of cacao mouldings are recognizable on dry fermented and unfermented Dominican cacao, namely: (1) Cacao moulding which gives a peculiar and disagreeable odor known as "mould odor" or "Actinomyces odor". This odor is caused by many species of the genus *Actinomyces.* Colonies of such common moulds as Mucorales and Hyphales may or may not be present. Strongly contaminated cacao frequently appears superficially covered with a whitish delicate dust which is composed of colonies and more or less fragments of the ray-fungi. (2) Cacao moulding without any particular odor, but showing a more or less luxuriant growth of mould fungi (Mucorales and Hyphales), composed of colonies which are blackish, brownish or green-bluish, rarely whitish to yellowish or reddish in color. Very frequently, the two types of moulding are associated, as the ray-fungi are almost constantly present on dry cacao beans, but the "Actinomyces odor" is clearly perceptible only if cacao seeds are intensively contaminated.

In a previous paper (**2**), the writer referred on the first type of cacao moulding. The most frequent and important ray-fungus is the *Actynomyces albus* Krainsky emend. Waksm. & Curt., with a local but scarcely distinguished variety *alpha* Cif.; also *A. griseus* Krainsky is present. The following moulds were isolated: *Rhizopus arrhizus* Fisch., *R. nigricans* Ehrenb., *Macrosporium commune* Rabenh., *Coniothecium effusum* Corda, *Botrytis vulgare* Fries, *Aspergillus fumigatus* Fres., *A. niger* V. Tiegh., *A. elegans* Gasp., *Fusarium* sp., *Spicaria lateritia* Cif.

The purpose of the present investigation, carried out during the years 1926 and 1927 was: (1) the study of numerical distribution of the mould spores on dry fermented and unfermented healthy cacao beans, as well as on moulded cacao beans; (2) the identification of isolated moulds; (3) the study of the comparative growth of the most frequent moulds on pasteurized fermented and unfermented cacao beans.

Scattered notices about moulds of cacao and cacao moulding are found in the literature on cacao, but the first satisfactory determinations of moulds were obtained from the studies of Dr. Thom of

cultures made by Dr. Schwarz from Gold Coast (Accra type) cacao (**26**). He found that several forms of *Aspergillus niger* and *A. flavus* group, were present in practically every phase of the culture work; *A. tamarii* was encountered in the beans taken from near the surface of the mass. He found also abundant Mucoraceace, chiefly species of *Rhizopus*, a few yeasts, and aerobic spore-forming bacteria, including bacteria of the *mesenteric group.**

Reinke (**23**) isolate 142 strains of Aspergilli from cacao, of which the most frequent were *Aspergillus flavus* and *A. niger* (75 per cent), *A. Sydowii* and *A. tamarii* (50 per cent); also *A. repens, A. terreus, A. carbonarius, A. versicolor* var. *flavipes, A. candidus, A. giganteus, A. ochraceus* and *A. versicolor.* From Haitian samples, he isolated *A. niger, A. tamarii, A. carbonarius* and *A. flavus.*

Green, brown, and black *Aspergilli,* six *Mucorales,* seven *Penicilli,* three *Cladosporium, Cephalothecium, Fusarium, Botrytis* and a Sphaeropsidaceous fungus were isolated from cacao beans of many African and American countries by Busse, Henneberg and Zeller (**1** bis).

EXPERIMENTAL PROCEDURE

Samples of fermented, unfermented and mixed (fermented and unfermented) cacao beans, of about one pound each, were taken from the store houses of the cacao farmers and traders of Moca, Santiago, La Vega, San Francisco de Macorís, Sánchez and Samaná, and carefully packed. As soon as possible, 25 beans from each sample were washed with 100 c.c. of sterile, distilled water. Holding firmly with a sterile forceps, each cacao bean was thoroughly scrubbed with a sterile stiff stencil brush. Duplicate plate cultures on Bacto prume agar were made, using five, ten, fifteen and twenty drops and one c.c. of thoroughly agitated wash water. To inhibit the growth of Schizomycetes, the substratun was mercurized to 1/10.000 (adding 1 c.c of one per cent solution of mercury chloride to 100 c.c. of prune agar), following the method of De Rossi (**10**). Each set of ten plates was incubated in the laboratory at ordinary room temperature (24–32° C.) during three days, and all apparently different colonies of fungi were isolated for later identification. Numbered stock cultures were subdivided in five groups, according

*** During the publication of this paper, I knew of the isolation and study of many other fungi isolated from cacao beans. Sartory A., Sartory R. and Meyer J. (Ann. Mycol. 28 (5–6): 362–362. 1930) isolated a species of *Aspergillus (A. halophilus)* from sample of cacao damaged by the contact with sea water and subsequently stored under warm condition I was informed of a few papers on this subject published in the English colonies of Africa, but without knowledge of the content, as well as of the bibliographical reference.**

to the results of a preliminary identification, namely: (1) Aspergilli forms, (2) Penicilli forms, (3) species of Mucorales, (4) mould fungi other than the preceding, (5) Saccharomycales and Torulopsidaceae (ascosporic and anascosporic yeasts).

The cacao used was the common cacao (so called Sánchez type), chiefly derivated from Calabacillo variety-group crosses. Samples marked *A* to *G* were taken from 1926 crop, and samples marked *H* to *L* from 1927 crop. The locality and quality of samples was the follow:

Sample A: mixed healthy cacao from Moca
Sample B: unfermented healthy cacao from Moca.
Sample C: fermented healthy cacao San Francisco de Macorís.
Sample D: mixed healthy cacao from San Francisco de Macorís.
Sample E: mixed healthy cacao from La Vega.
Sample F: mixed healthy cacao from Samaná.
Sample G: mixed moulded cacao from Moca.
Sample H: mixed healthy cacao from Santiago.
Sample I: unfermented healthy cacao from San Francisco de Macorís.
Sample J: fermented healthy cacao from San Francisco de Macorís.
Sample K: mixed moulded cacao from Samaná.
Sample L: mixed moulded cacao from Sánchez.

NUMERICAL DISTRIBUTION OF MOULD FUNGI

The numerical distribution of spores of mould fungi per cacao bean (colony counts) * was as follows:

Sample	Per cent Mucorales of	Per cent of Aspergilli	Per cent of Penicilli	Per cent of other moulds	Total number of colonies
A	32	41	21	6	700
B	46	39	7	8	1,400
C	17	66	15	2	1,300
D	56	38	5	1	1,700
E	39	44	13	4	1,900
F	54	41	5	0	4,200
G	48	36	15	1	89,500
H	39	47	13	1	3,000
I	60	21	16	3	4,700
J	40	54	5	1	600
K	67	18	15	0	67,100
L	74	24	2	0	38,900
Average	48	39	10	3	17,917

AVERAGES

Average of mould spores on mixed healthy cacao (samples A, D, E, F and H): 2300.
Average of mould spores on fermented healthy cacao (samples C and J): 950.
Average of mould spores on unfermented healthy cacao (samples B and I): 3050.
Average of mould spores on mixed moulded cacao (samples G, K, and L): 65270.

* True and anascosporic yeasts, besides as scarce as 0, 1 per cent or less, will be studied in another section of this paper.

IDENTIFICATION OF THE MOULD FUNGI

Group (1) Aspergilli. The systematic and nomenclature of Thom and Church (1) has been followed. Colonies, growing on Czapeck's solution agar, were incubated in the Laboratory at room temperature. In view of the fact that the isolated *Aspergillus* strains, are not specialized on cacao, but are more or less saprophytic forms, the identification was frequently limited to the forms-group only.

Strains N. 12, 15, 31, 56 and 60 belong to the *Aspergillus niger* group, and probably, should be determined as *A. niger* V. Tiegh., an exceedingly variable form. This species is present in almost all cultures in Petri dishes, and is frequently the most abundant mould.

Strains N. 17, 26, 29, 34, 40 and 48 belong to the *A. fumigatus* group, but I have never seen the perithecial forms. This mould is as frequent as the preceding group-species.

Strains 18, 19, 42, 46 and 59 belong to the *A. glaucus* group, and this species is very frequent, but only in certain samples (A, B, D, G, K, L).

Strain N. 38 and 39 belong to the *A. tamarii* group, and is perhaps identic with *A. tamarii*. As in the preceding, this form is frequent only in certain samples (samples *F*, *K* and *L*).

Strains 22, 24 and 52 belong to the *A. nidulans* group; strains N. 22 and 24, isolated from the sample G, are probably identical with the true *A. nidulans*.

Strains N. 30, 36, 44 and 68 belong to the *A. flavus* group. Strains of this group are as frequent as the *A. niger* and *A. fumigatus*.

Strain N. 67 belong to the *A. versicolor* group. A rare form isolated only from the sample *D*.

Strain N. 85 belong to the group of *A. candidus*. As in the preceding, but from the sample *J*.

Group (2) Penicilli. The study published by Biourge has been followed, and the cultures grown on Raulin-Diercky and on Hayduk solutions, etc., are made according the procedure described in Biourge's monograph and at room temperature.

Strains 32, 54 bis, 58 and 82.—*Penicillium leucopus* (Pers.) Biourge. This form, probably corresponding to *Penicillium glaucum* or *P. crustaceum* Auct. pl., is the one most frequently seen on cultures in Petri dishes, but never as abundant as the blackish Aspergilli.

Strains N. 43 and 64.—*P. notatum* West. An unfrequent form, isolated from the samples D and G.

Strain N. 51.—A form allied with *P. luteum* (Zuk.) Thom (fide Biourge) isolated from the sample H, and here very frequent.

Strain N. 33.—This strain is definite, but very doubtfully, as the *P. roseum* Link, a classic but from the modern point of view, not clearly definite species. It is not considered in Biourge's monograph. It was isolated from the sample E only once.

Strains N. 77 and 80.—These strains are identical with or allied to *P. candidum* Roger (nec Link, fide Biourge), and were isolated from samples J and K. Found also as indefinite, small, arachnoid colonies on moulded cacao beans.

Group (3) Mucorales. Species of this order were studied and classified following the technic and the systematic and nomenclature of Lendner (**18**).

Strains N. 14, 20, 24, 53 and 65.—These strains, isolated from the samples A, C, D, G, H and K, were referable to *Rhizopus nigricans* Ehr.

Strains N. 35, 65 and 83.—*Rhizopus arrhizus* Fisch, isolated from the samples G, K, and L.

Strains N. 22 bis, 75 and 87.—These strains must be referred to *Mucor mucedo* L., a mould as frequent as the *Rhizopus nigricans* in all moulded cacao beans.

Strain N. 74.—This strain, isolated from the sample I, is closely allied or, probably, identic with *Mucor racemosus* Fres.

Group (4) Mould fungi other than Aspergilli, Penicilli and Mucorales. The species of Hyphales isolated from cacao beans were identified following the systematic treatment of this group by Lindau (**20**) and Ferraris (**12**). Cultures were made using many solid media, chiefly Bacto prune agar, peptonized potato agar and carrot agar.

Strains 22, 30, 58 and 71.—All these strains must be referred to *Spicaria lateritia* Cif., one of the saprophytic fungi most universally distributed in the Dominican Republic. It is, also, one of the most frequent contaminaters of cultures. Conidia are present in the air, in water, in soil, etc. It forms large and beautiful colonies, orange or lateritic-red in color, on partially burned wood during the rainy seasons or in moist places.

Strains N. 13, 21, 74 and 79.—All these strains are referable to *Cephalosporium acremonium* Corda, a mould almost as frequent as *Spicaria lateritia.*

Strains N. 39 and 50.—Another largely distributed mould, referred to *Trichothecium roseum* Link.

Strain N. 25.—This strains must be referred to a new species of *Helminthosporium*, a saprophyte described as *H. cacaophilum* Cif., very distinct from *H. theobromicolum* Cif. and *H. theobromae* Turc. Found only in the sample B.

Strain N. 45.—Belongs to *Macrosporium commune* (Rabenh.) Sacc., as conventionally understood. This is an unfrequent mould, isolated twice from sample A.

Strains N. 33, 63 and 73.—This mould was isolated three times from samples B, E, and G, but is probably more common. It is not different from *Pullularia pullulans* (De By.) Berkh., commonly called *Dematium pullulans* De Bary.

Strains N. 37 and 47.—Belongs to *Alternaria tenuis* Nees, and was isolated twice from samples G. and H. About the 50 per cent of the colonies isolated from the sample H are composed of this fungus.

Strain N. 41.—*Catenularia fuliginea* Saito, a rare species found only in the sample F.

Strain N. 65.—For this strain I am describing a new species of the genus *Dendryphium* (*D. congestum* Cif., n. sp.). It was found in the sample L, growing in a single colony.

Strain N. 38.—This strain is of doubtful identification; apparently it belongs to *Coniothecium effusum* Corda. It was found in a single colony from the sample C.

Strain N. 66.—Found in a single colony from cultures derivated from sample K. It was referred to a new genus and new species, *Blastoconium tropicum* Cif., n. gen. et n. sp.

Strain N. 79.—Isolated from sample B and doubtfully referred to *Hormodendron pallidum* Oudem.

Strain N. 55.—*Fusarium sarcochroum* (Desm.) Sacc., or an allied form, isolated from sample K.

Strain N. 78.—This strain must be referred to a slightly different variety of *Fusarium zonatum* (Sherb.) Wollenw., but its systematic position is doubtful. It was isolated from sample G.

GROWTH OF MOULDS ON CACAO BEANS

With a few exceptions, the isolation of a mould from cacao beans does not demonstrate the possibility of a luxuriant growth on the same, or, in other words, that the fungus must be considered as one of the causes of cacao moulding.

The inoculations were made by spraying a suspension of the conidia (from cultures in Petri dishes) in distilled sterilized water with a small atomizer on: (1) fermented uncut cacao beans, (2) fermented cut beans, (3) unfermented uncut cacao beans, (4) unfermented cut beans. Before the inoculation, the four samples of cacao beans were washed with 0.2 per cent solution of mercury bichloride and repeatedly re-washed with sterilized destilled water, and then enclosed in four ample dessiccators partially filled with water, during four days. After the water imbibition by cacao beans, each sample was divided in twenty small samples, all of which was inoculated with one of the isolate moulds, and enclosed in a common sterilized drinking-glass, closed by a photographic plate glass and sealed with paraffine. The set of eighty glasses were kept during thirty days in incubation at the laboratory temperature, and then opened and the growths of moulds observed as appearing to the naked eye. Of the isolated moulds, only twenty forms, appearing as the most frequent, were inoculated. The results are summarized as follows:

(The sign O signifiy no growth; ? doubtful growth; + scarce development; + + abundant development; + + + very abundant development).

Mould	Fermented cacao		Unfermented cacao	
	Cut beans	Uncut beans	Uncut beans	Uncut beans
Aspergillus niger	+ + +	+ + +	+ + +	+ + +
Aspergillus fumigatus	+ + +	+ + +	+ + +	+ + +
Aspergillus glaucus	+	+	+ +	+ +
Aspergillus tamarii	+	?	+	?
Aspergillus nidulans	0	0	+	+
Aspergillus flavus	+	+	+ +	+ +
Aspergillus versicolor	0	?	?	?
Aspergillus candidus	0	0	0	?
Penicillium leucopus	+	+	+	+
Penicillium notatum	0	0	0	0
Penicillum luteum	0	0	?	+
Penicillium roseum	0	0	?	?
Penicillium candidum	0	?	+	+
Spicaria lateritia	0	0	0	?
Cephalosporium acremonium	0	0	0	0
Trichothecium roseum	0	0	?	0
Pullularia pullulans	0	0	0	0
Alternaria tenuis	0	0	?	+
Rhizopus nigricans	+ +	+ +	+ + +	+ + +
Rhizopus arrhizus	+	+	+	+
Mucor mucedo	+ +	+ + +	+ +	+ + +
Mucor racemosus	0	0	?	?

DISCUSSION OF THE RESULTS

The number of strains and mould forms isolated from cacao beans should be summarized as follows:

(1) **Aspergilli**: 27 strains, 8 forms.

(2) Penicilli: 10 strains, 5 forms.
(3) Mucorales: 12 strains, 4 forms.
(4) Mould others than the preceding: 24 strains, 14 forms.

These strains derived from the following cacao beans samples:

Sample A: 10 forms.
Sample B: 11 forms.
Sample C: 9 forms.
Sample D: 11 forms.
Sample E: 8 forms.
Sample F: 10 forms.
Sample G: 16 forms.
Sample H: 10 forms.
Sample I: 8 forms.
Sample J: 9 forms.
Sample K: 16 forms.
Sample L: 12 forms.

Or, in relation to the quality of cacao, an average of:

Mixed healthy cacao: 10 forms.
Unfermented healthy cacao: 10 forms.
Fermented health cacao: 9 forms.
Mixed moulded cacao: 15 forms.

As one may expect, the fermented healthy cacao beans are the poorest in forms of moulds, and moulded cacao the richest. Mixed and unfermented cacao are equally rich in forms of moulds, and intermediary between the preceding samples.

Aspergilli are the most frequent moulds, and the group is the richest in forms. Penicilli and Mucorales are almost of the same importance. The following species are normally present in samples of cacao beans: *Aspergillus niger; A. fumigatus; A. flavus; A. glaucus; Penicillium leucopus; Rhizopus nigricans; Mucor mucedo; Spicaria lateritia; Cephalosporium acremonium.* Mucorales are the most abundant as to number of spores, then Aspergilli, Penicilli and, last, other Hyphales.

These results agree well with the observation made by Schwarz in Gold Coast on Accra cacao beans, and in relation to the isolated forms, with the preliminary experiments of the writer.

SUMMARY

The writer refers to the results of isolation from and inoculation of fermented and unfermented cacao beans of mould fungi. A new genus and two new species of Dematiaceae are described.

MYCOLOGICAL OBSERVATIONS AND DESCRIPTIONS OF STRAINS

Strain N. 25.—*Helminthosporium cacaophilum* Cif., n. sp. (Description from cultures.)

At the room temperature, the colonies develop easily; colony 5 days old is from 20 to 45 mm. in diameter. It is composed of a well developed system

of myceliar hyphae, without clearly differentiated conidiophores, and a few scattered conidia. The colony is, at first, white and tufted, then sub-lanose and developed in concentric but not well defined rings, varying from light-gray to dull-gray, with black shades. Mycelium abundant, composed of densely but irregularly branched hyphae, septate, containing droplets and refringent corpuscula, generally from 2 to 3.5 mmm. in diameter. Short lateral sub-erected myceliar branches 15–25 mmm. in length, may produce a few conidia, acrogenous or pleuro-acrogenous, inserted on small teeth. Conidia brown to grayish, from 5 to 13-septate, generally 7–10-septate, ellipsoid to ovoid, free and more or less rounded, basal end sub-acuminate, 65 to 94 mmm. in length, 10 to 15.5 mmm. width. Isolated from unfermented healthy cacao beans from Moca, Dominican Republic.

Strain N. 63.—*Dendryphium (Brachycladium) congestum* Cif., n. sp. (Description from cultures).

At room temperature, this fungus grows readily covering almost all the surface of the Petri dish. The colonies are flattened, at first black-greenish, then blackish, smooth, opaque, with a very poor aerial development. The mycelium is brownish, septate, densely branched, and developed abundantly only under the surface of the solid substratum, 2–3 mmm. in thickness. The conidiophores emerge from the substrata, but are sub-erect to prostrate, more or less straight, with a few septa, unbranched or scarcely branched, 20–50 mmm. by 2–3.5 mmm. The conidia are normally aerogenus, very rarely acro-pleurogenous, isolated or, more frequently, from 2 to 6-chained, 3–5-septate, smoky, clearly narrowed at the septa, from elliptic to ovoid, 14–33 by 4.58 mmm. Isolated from mixed moulded cacao beans from Sánchez, Dominican Republic.

Strain N. 66.—*Blastoconium* Cif., n. gen. (Hyphales, Dematiaceae, Phaerdictyae, Coniothecieae).

Similar to the genus *Coniothecium* Corda, but with sterile hyphae torulose-moniliform, from which each single isolated element (chlamydospore) may reproduce itself by budding. As in the genus *Coniothecium,* true conidiophores are absent, and the conidia are transversally and longitudinally septate.

Blastoconium tropicum Cif., n. sp. (Description from cultures).

Develop easily at room temperature. The colonies are, at first very similar to the colonies of the *Pullularia pullulans,* repeating the *Dematium*-like stage of most of the Dematiaceae; the growth of the underground part is more active than the superficial growth. The colonies are smoky to blackish, then black, smooth, humid. The mycelium is composed of branched hyphae, densely septate, at first narrowed at the septa, then producing by budding one or two lateral daughter cells. The daughter cells may separate and reproduce by budding or not, in the last case forming two cells more or less of the same size. Successively, the number of cells constituting the chain increases and branches, and at the same time a number of blastospores become deeper in color while the membrane increases in thickness. The final result is the presence of monilioid or torulose chains, composed of spheric or sphered, elliptic, ovoid, cylindric or irregularly-shaped elements, normally unseptated, rarely transversally septate, very variable in size, from 4

to 15 mmm. in diameter or in length. A few monilioid hyphae may be produced only on the surface of the solid substratum (exceptionally on liquid media) one isolated conidium, apparently generated from one aerial bud of the terminal chlamydospore, clearly distinct from the mother cell. The conidium is irregular in shape, more frequently elliptic or sub-cylindric, from 1-septate to 3-septate, but in many cases with a longitudinal irregular septum; the size of the conidia is 6–17 by 4–12 mmm. Isolated from mixed moulded cacao beans from Samaná, Dominican Republic.

This genus, like *Dematium* or *Pullularia*, probably represents the most primitive and imperfect stage of development of unknown Dematioid fungi.

According the deescription, *Coniothecium glumarum* Sacc. (Syll. fung., Vol. XIV, p. 1092, 1899) found on *Phragmites communis* in Hungary, must be referred to this genus as BLASTOCONIUM GLUMARUM (Sacc.) Cif., n. comb. This species was described as having torulose-septate hyphae, and the microconidia are probably not other than the young bud-cells of the chlamydospores.

Strain N. 55.—*Fusarium ? sarcochroum* (Desm.) Sacc. Sect. *Latcritium* Woll. Microconidia trichothecioid, 1–3 septate, 12–25 by 4–10 mmm.; macroconidia 3–6 septate, 25–52 by 3–6 mmm.

Strain N. 78.—*Fusarium ? zonatum* (Sherb.) Woll. Sect. *Elegans* Woll., Subsect. *Oxysporum* Woll., Ser. *Pallens* Woll. Sporodochial confluent gelatinous stroma; microconidia very abundant, 4–10 by 2–4 mmm.; macroconidia 32–64 by 3–6 mmm. Probably a form of the species.

III. CACAO MOULDING

This study, made in combination with previous reports on this same subject, was performed in order to determine: (1) the environmental factors and conditions influencing the development of mould fungi, chiefly in relation to (*a*) moisture content of cacao beans; (*b*) moisture absorption and loss of the same; (*c*) temperature; (2) the determination of the critical point of moulding; (3) the prevention of moulding.

As in the preceding, the studies were made both on fermented and unfermented Dominican cacao, Sánchez type.

Preliminary observation having indicated that the most important role is played by moisture content of cacao beans, this factor was studied most accurately. At the same time, a few observation were made for determination of many constants of Dominican cacao, such as average dry weight, specific weight and size of beans.

ORIGIN OF THE SAMPLES

The origin of the samples and the type of cacao beans was the following:

Sample N. 1.—Mixed cacao from Moca (marked S. B.).
Sample N. 2.—Mixed cacao from Moca (marked E. P.).
Sample N. 3.—Fermented cacao from Moca (marked E. N. A.).
Sample N. 4.—Fermented cacao from Moca (marked E. N. A.).
Sample N. 5.—Unfermented cacao from Moca (marked E. N. A.).
Sample N. 6.—Unfermented cacao from Moca (marked E. N. A.).
Sample N. 7.—Fermented cacao from La Vega (marked E. G. G.).
Sample N. 8.—Fermented cacao from La Vega (marked E. G. G.).
Sample N. 9.—Unfermented cacao from La Vega (marked E. G. G.).
Sample N. 10.—Unfermented cacao from La Vega (marked E. G. G.).
Sample N. 11.—Unfermented cacao from Bonao (marked J. J.).
Sample N. 12.—Unfermented cacao from Bonao (marked J. J.).
Sample N. 13.—Unfermented cacao from San Cristóbal.
Sample N. 14.—Mixed cacao from San Cristóbal.
Sample N. 15.—Fermented cacao from San Francisco de Macorís (marked J. M. A.).
Sample N. 16.—Fermented cacao from San Francisco de Macorís (marked B. J. R.).
Sample N. 17—Unfermented cacao from San Francisco de Macorís.
Sample N. 18.—Unfermented cacao from San Francisco de Macorís.
Sample N. 19.—Unfermented cacao from Pimentel.
Sample N. 20.—Mixed cacao from Pimentel.
Sample N. 21.—Unfermented cacao from Villa Rivas.
Sample N. 22.—Mixed cacao from Villa Rivas.
Sample N. 23.—Unfermented cacao from Samaná.
Sample N. 24.—Mixed cacao from Samaná.

NORMAL MOISTURE CONTENT AND DRY WEIGHT OF CACAO BEANS

This constant was determined by taking the actual weight of samples of 100–500 cacao beans, and drying at 100–105°C.

ACTUAL WEIGHT, DRY WEIGHT AND MOISTURE CONTENT OF CACAO BEANS

Sample No.	Average of	Actual weight gr.	Moisture content per cent	Dry weight gr.	Observations
1	100 seeds	1, 068	19	0, 865	
2	100 seeds	1, 059	21	0, 837	
3	500 seeds	0, 949	15	0, 807	
4	500 seeds	0, 936	14	0, 805	
5	500 seeds	1, 020	18	0, 836	
6	500 seeds	1, 059	19	0, 858	
7	200 seeds	0, 970	16	0, 815	
8	200 seeds	0, 945	15	0, 803	
9	200 seeds	1, 081	20	0, 865	
Average	2, 800 seeds	1, 010	19	0, 832	General average
Average	200 seeds	1, 064	20	0, 851	Average of mixed cacao beans
Average	1, 400 seeds	0, 922	15	0, 808	Average of fermented cacao beans
Average	1, 200 seeds	1, 053	19	0, 820	Average of unfermented cacao beans

SPECIFIC WEIGHT OF CACAO BEANS

This constant was determined using the pycnometric method. First observations were made by filling the pycnometer with mercury, but the great difference in the specific weight of mercury and that of cacao beans gave many difficulties. The following measurements were made using graduate cylinders filled with distilled water, having observed that the absorbed water does not affect the determinations, if they are made sufficiently rapid. Of course, the precision of this specific weight is reduced.

SPECIFIC WEIGHT OF CACAO BEANS (SAMPLE OF 6 BEANS EACH)

	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 5
	0, 991	0, 974	0, 891	0, 890
	0, 983	0, 972	0, 890	0, 890
	0, 986	0, 968	0, 890	0, 893
	0, 987	0, 966	0, 887	0, 895
	0, 988	0, 973	0, 884	0, 894
	0, 986	0, 974	0, 883	0, 890
	0, 990	0, 974	0, 884	0, 885
	0, 984	0, 975	0, 887	0, 886
	0, 988	0, 976	0, 888	0, 887
	0, 986	0, 972	0, 886	0, 890
Average	0, 987	0, 971	0, 887	0, 890

Average of mixed cacao	0, 979
Average of fermented cacao	0, 887
Average of unfermented cacao	0, 890

The differences between the specific weight of samples Nos. 1 and 2 composed of mixed cacao, are probably caused by the different contents of moisture (undetermined).

SIZE OF CACAO BEANS

Fifty unselected cacao beans from each sample were measured; the figures of table express the maximum length, maximum breadth and the maximum thickness.

SIZE OF CACAO BEANS

Sample N. 1 (mixed cacao).

Length mm.:	16	17	18	19	*20*	21	22	23	24	25	
Frequency N.:	1	1	7	8	10	7	8	5	1	2	=50

Breadth mm.:	10	11	*12*	13	14	15	16	
Frequency N.:	3	4	17	13	9	3	1	=50

Thickness mm.:	4	5	6	7	8	*9*	10	11	12	13	
Frequency N.:	1	2	9	8	11	12	3	3	0	1	=50

Sample N. 2 (mixed cacao)

Length mm.:	16	17	18	19	20	*21*	22	23	24	25	
Frequency N.:	1	0	2	2	8	13	10	5	7	2	=50

Breadth mm.:	10	11	*12*	13	14	15	16	17	18	19	
Frequency N.:	2	5	15	14	10	3	0	0	0	1	=50

Thickness mm.:	4	5	6	*7*	8	9	10	11	
Frequency N.:	2	4	6	16	14	5	2	1	=50

Sample N. 3 (fermented cacao)

Length mm.:	16	17	18	19	*20*	21	22	23	24	25	26	
Frequency N.:	1	3	7	10	19	17	17	13	6	4	3	=100

Breadth mm.:	7	8	9	10	11	*12*	13	14	15	16	17	
Frequency N.:	1	0	0	4	10	30	24	27	7	0	2	=100

Thickness mm.:	3	4	5	6	*7*	8	9	10	11	12	13	
Frequency N.:	1	2	14	22	32	13	4	6	3	2	1	=100

Sample N. 5 (unfermented cacao)

Length mm.:	16	17	18	19	*20*	21	22	23	24	25	26	27	28	29	30	
Frequency N.:	2	4	2	13	19	14	9	9	13	11	1	2	0	0	1	=100

Breadth mm.:	9	10	11	12	*13*	14	15	16	17	18	
Frequency N.:	2	2	11	22	27	18	11	4	1	2	=100

Thickness mm.:	4	5	6	*7*	8	9	10	11	12	
Frequency N.:	1	5	22	29	22	11	8	1	1	=100

Average of the samples N. 1 and 2 (mixed cacao)

Length mm.:	16	17	18	19	20	*21*	22	23	24	25	
Frequency N.:	2	1	9	10	18	20	18	10	8	4	=100

Breadth mm.:	10	11	*12*	13	14	15	16	17	18	19	
Frequency N.:	5	9	32	27	19	6	1	0	0	1	=100

Thickness mm.:	4	5	6	7	*8*	9	10	11	12	13	
Frequency N.:	3	6	15	24	25	17	5	4	0	1	=100

These figures may be summarized as follows:

Mixed cacao: 16–25 by 16–19 by 4–13 mm.. most frequently 21 by 12 by 8 mm.

Fermented cacao: 16–26 by 7–17 by 3–13 mm., most frequently 20 by 12 by 7 mm.

Unfermented cacao: 16–22 by 9–18 by 4–12 mm., most frequently 20 by 13 by 7 mm.

WATER IMBIBITION OF CACAO BEANS

Three samples of 120 cacao beans were submersed in distilled water at 40° C., superficially dried using bibulous paper and weighed after 24 and 48 hours of immersion.

Sample N. 14 (mixed cacao)

Initial weight	gr. 1, 311 = 100
After 24 hours	gr. 1, 550 = 118
After 48 hours	gr. 1, 550 = 118

Sample N. 15 (fermented cacao)

Initial weight	gr. 1, 139 = 100
After 24 hours	gr. 1, 306 = 115
After 48 hours	gr. 1, 306 = 115

Sample N. 17 (unfermented cacao)

Initial weight	gr. 1, 228 = 100
After 24 hours	gr. 1, 478 = 120
After 48 hours	gr. 1, 478 = 120

LOSS IN WEIGHT OF CACAO BEANS EXPOSED TO THE SUNSHINE

Five samples of fermented cacao and five samples of unfermented cacao, varying from 10 to 25 kg. each, were exposed to the direct sunshine 11 hours; 7 hours the first day (from 9 A. M. to 4 P. M. August 26, 1927) and 4 hours the second day (from 8 A. M. to 11 A. M. August 27, 1927). These days were very warm, the temperature varying from 24 to 35° C. and from 24 to 34° C. Losses in weight are expressed in percentages.

PER CENT OF LOSS IN WEIGHT OF CACAO BEANS EXPOSED TO THE SUNSHINE

Hours	Sample No. 3	Sample No. 4	Sample No. 7	Sample No. 8	Sample No. 5	Sample No. 5	Sample No. 6	Sample No. 9	Sample No. 10	Sample No. 24	Average for hour	
											Fermented beans	Unfermented beans
1st	0,37	0,28	0,33	0,45	0,38	0,38	0,79	0,48	0,80	1,10	0,36	0,71
2nd	0,35	0,14	0,14	0,26	0,16	0,16	0,32	0,35	0,49	0,68	0,21	0,40
3rd	0,35	0,20	0,04	0,27	0,19	0,13	0,29	0,25	0,31	0,48	0,20	0,29
4th	0,29	0,10	0,21	0,24	0,17	0,17	0,24	0,25	0,35	0,41	0,21	0,28
5th	0,27	0,12	0,07	0,25	0,12	0,06	0,20	0,14	0,18	0,10	0,15	0,13
6th	0,16	0,05	0,02	0,08	0,09	0,10	0,08	0,08	0,07	0,00	0,04	0,06
7th	0,00	0,00	0,00	0,04	0,00	0,04	0,00	0,00	0,03	0,00	0,00	0,01
(Night)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)
8th	0,00	0,00	0,18	0,08	0,11	0,14	0,10	0,06	0,05	0,00	0,13	0,07
9th	0,28	0,18	0,16	0,23	0,15	0,14	0,27	0,12	0,28	0,52	0,20	0,27
10th	0,20	0,13	0,10	0,19	0,13	0,08	0,07	0,12	0,12	0,26	0,13	0,13
11th	0,14	0,10	0,10	0,11	0,14	0,10	0,05	0,15	0,12	0,11	0,10	0,11
Total	2,42	1,31	1,34	2,19	1,64	1,50	1,50	1,99	2,71	3,66	1,78	2,27

(The increase in weight during the night, if any, was not considered, and the weight was calculated on the basis of the 7th hour).

These results are graphically expressed in the diagram of plate XXVIII.

WATER VAPOR IMBIBITION OF CACAO BEANS

Ten samples of cacao beans (five of fermented cacao and five of unfermented cacao), composed of 20 seeds each, were exposed to saturated water vapor (100 per cent, or absolute humidity) at the temperature of the Laboratory (about 24 to 32° C.) during five days. For this purpose, the samples were enclosed in two moist chambers. The increase in weight is expressed in per cent of the initial weight.

PER CENT OF INCREASE IN WEIGHT OF CACAO BEANS EXPOSED TO THE SATURATED WATER VAPOR

Sample No.	First day	Second day	Third day	Fourth day	Fifth day	Total
4	0, 00	0, 47	0, 32	0, 01	0, 00	0, 80
7	0, 00	0, 24	0, 25	0, 06	0, 01	0, 56
8	0, 00	0, 26	0, 27	0, 01	0, 00	0, 62
15	0, 00	0, 46	0, 34	0, 06	0, 00	0, 63
16	0, 00	0, 41	0, 34	0, 01	0, 00	0, 56
Average of fermented beans	0, 00	0, 37	0, 30	0, 03	0, 01	0, 63
17	0, 00	0, 22	0, 35	0, 00	0, 00	0, 56
18	0, 00	2, 12	0, 65	0, 00	0, 00	2, 77
19	0, 00	0, 20	0, 37	0, 00	0, 00	0, 57
21	0, 00	0, 33	0, 65	0, 01	0, 00	1, 00
23	0, 00	2, 38	0, 59	0, 00	0, 00	2, 95
Average unfermented	0, 00	1, 07	0, 52	0, 00	0, 00	1, 57

These figures are represented in the graph of the plate XXIX.

WATER VAPOR ABSORTION OF CACAO BEANS DRIED AT DIFFERENT TEMPERATURES

Two samples of cacao beans (one of fermented and one of unfermented cacao), composed of 20 beans each, were dried until of constant weight at different temperatures, ranging from 40° C. to 100° C., then exposed to the saturated water vapor (in a moist chamber) during ten days, and weighted. The moist chamber was situated, as in the preceding experiment, in the laboratory. The increase in weight at the end of the experiment is expressed in per cent as related to dry weight.

PER CENT OF INCREASE IN WEIGHT OF CACAO BEANS DRIED TO DIFFERENT TEMPERATURES AND EXPOSED TO SATURATED WATER VAPOR

FERMENTED CACAO (SAMPLE NO. 15)

Day	Drying temperature degrees C.							Total
	40	50	60	70	80	90	100	
First	0, 51	0, 49	0, 28	0, 11	0, 13	0, 09	0, 08	1, 69
Second	0, 29	0, 27	0, 19	0, 18	0, 09	0, 11	0, 09	1, 22
Third	0, 28	0, 13	0, 12	0, 09	0, 10	0, 10	0, 09	0, 91
Fourth	0, 01	0, 04	0, 05	0, 02	0, 06	0, 03	0, 05	0, 26
Fifth	0, 00	0, 01	0, 00	0, 02	0, 01	0, 05	0, 02	0, 11
Sixth	0, 01	0, 00	0, 02	0, 01	0, 00	0, 02	0, 05	0, 10
Seventh	0, 00	0, 02	0, 00	0, 02	0, 01	0, 02	0, 03	0, 10
Eighth	0, 00	0, 00	0, 00	0, 00	0, 01	0, 01	0, 01	0, 03
Ninth	0, 00	0, 00	0, 00	0, 02	0, 00	0, 00	0, 01	0, 03
Tenth	0, 00	0, 01	0, 00	0, 00	0, 01	0, 00	0, 01	0, 03
Total	1, 10	0, 97	0, 66	0, 47	0, 42	0, 43	0, 44	4, 48

UNFERMENTED CACAO (SAMPLE NO. 17)

Day	Drying temperatures degrees C.							Total
	40	50	60	70	80	90	100	
First	0, 23	0, 20	0, 21	0, 18	0, 15	0, 12	0, 13	1, 22
Second	0, 12	0, 10	0, 20	0, 12	0, 15	0, 16	0, 10	0, 95
Third	0, 09	0, 11	0, 19	0, 13	0, 09	0, 10	0, 09	0, 80
Fourth	0, 11	0, 12	0, 09	0, 06	0, 08	0, 10	0, 09	0, 65
Fifth	0, 07	0, 05	0, 10	0, 08	0, 08	0, 11	0, 14	0, 73
Sixth	0, 02	0, 06	0, 09	0, 09	0, 07	0, 12	0, 17	0, 62
Seventh	0, 05	0, 07	0, 08	0, 10	0, 07	0, 03	0, 12	0, 52
Eigth	0, 06	0, 05	0, 11	0, 09	0, 08	0, 06	0, 08	0, 53
Ninth	0, 04	0, 08	0, 09	0, 03	0, 01	0, 05	0, 05	0, 35
Tenth	0, 08	0, 04	0, 05	0, 07	0, 08	0, 05	0, 00	0, 35
Total	0, 88	0, 88	1, 21	0, 95	0, 86	0, 90	0, 97	6, 62

These results referred also in the clivoids of plate XXX.

DAILY VARIATION OF WEIGHT OF CACAO BEANS AS RELATED TO THE AVERAGE OF AIR HUMIDITY

Specimens of 2 kg. each of both fermented and unfermented cacao beans were taken from the samples N. 3 and 5, and weighted three times per day, at 7 A. M., at 1 P. M. and at 5 P. M. The average of weights were divided in classes of 10 gr. each, from 2000 gr. to 2080 gr. These averages were compared with the average of daily relative humidity, taken three times at the same hours. The results were the following:

Unfermented cacao (Sample N. 5)

Weight gr.																
2000 to	Humidity %	69	75	77	80	81	82	83	84	85	87	88	90	91
2010	Frequency N.	1	1	2	3	2	2	4	5	1	1	5	2	7
	Humidity %	92	94	95	96	97	100							
	Frequency N.	7	1	3	4	2	1							

Weight gr.													
2011 to	Humidity	%	63	69	72	76	80	83	87	88	91	95	96
2020	Frequency	N.	1	1	1	3	1	1	3	1	5	2	3
2021 to	Humidity	%	72										
2030	Frequency	N.	1										
2031 to	Humidity	%	60	62	64	69	83						
2040	Frequency	N.	1	1	1	1	2						
2041 to	Humidity	%	64	69	76	87							
2050	Frequency	N.	1	1	1	1							
2051 to	Humidity	%	75	76	83	87	91						
2060	Frequency	N.	1	1	1	1	2						
2061 to	Humidity	%	62	69	73	83	96						
2070	Frequency	N.	1	1	1	1	1						
2071 to	Humidity	%	76										
2080	Frequency	N.	1										

Fermented cacao (Sample N. 3)

2000 to	Humidity	%	60	63	69	72	75	76	77	80	81	82	83	85	87
2010	Frequency	N.	1	3	2	3	1	1	4	1	3	4	1	1	5
	Humidity	%	88	90	91	92	94	95	96	97	100				
	Frequency	N.	4	2	3	1	3	1	1	2	1				
2011 to	Humidity	%	69	72	76	80	83	87	91	95	96	97			
2020	Frequency	N.	1	2	1	1	3	1	2	2	4	2			
2021 to	Humidity	%	76	77	91	95									
2030	Frequency	N.	1	2	1	1									
2031 to	Humidity	%	62	64	69	76	80	87							
2040	Frequency	N.	1	2	3	1	1	2							
2041 to	Humidity	%	62	64	69	72	76	77	91						
2050	Frequency	N.	1	2	1	2	1	1	1						
2051 to	Humidity	%	69	73	76	77	83	95	96	97					
2060	Frequency	N.	1	2	1	1	1	1	1	1					

It should be noted that the cacao beans were exposed in the open air, during several days and nights.

These results are represented in the diagram of plate XXXI.

HOURLY RECORD OF THE VARIATIONS IN WEIGHT OF CACAO BEANS

Two samples of 500 gr. each of fermented and unfermented cacao beans were taken and left to the open air. During 24 consecutive

hours, and each 15 minutes, the samples were weighted and the relative humidity recorded. The results were as follows:

HOURLY RECORDS OF VARIATIONS IN WEIGHT OF CACAO BEANS AND VARIATIONS OF RELATIVE HUMIDITY

Fermented Cacao Sample No. 3				Unfermented Cacao Sample No. 5			
Hour	Weight gr.	Per cent variations	Relative humid.	Hour	Weight gr.	Per cent variations	Relative humid.
6 p. m.	500, 0	+ 0, 00	91	6 p. m.	500, 0	+ 0, 00	92
6, 15 p. m.	500, 2		96	6, 15 p. m.	500, 1		92
6, 30 p. m.	500, 4		96	6, 30 p. m.	500, 1		91
6, 45 p. m.	500, 6		96	6, 45 p. m.	500, 2		91
7 p. m.	500, 8	+ 0, 16	96	7 p. m.	500, 3	+ 0, 06	91
7, 15 p. m.	501, 0		96	7, 15 p. m.	500, 4		91
7, 30 p. m.	501, 3		96	7, 30 p. m.	500, 5		91
7, 45 p. m.	501, 5		96	7, 45 p. m.	500, 5		91
8 p. m.	501, 7	+ 0, 34	96	8 p. m.	501, 2	+ 0, 24	91
8, 15 p. m.	501, 8		96	8, 15 p. m.	501, 7		96
8, 30 p. m.	501, 9		96	8, 30 p. m.	502, 1		96
8, 45 p. m.	502, 0		96	8, 45 p. m.	502, 2		96
9 p. m.	502, 3	+ 0, 46	96	9 p. m.	502, 4	+ 0, 48	96
9, 15 p. m.	502, 3		96	9, 15 p. m.	502, 5		96
9, 30 p. m.	502, 4		96	9, 30 p. m.	502, 6		95
9, 45 p. m.	502, 5		96	9, 45 p. m.	502, 8		95
10 p. m.	502, 6	+ 0, 52	96	10 p. m.	502, 9	+ 0, 58	95
10, 15 p. m.	502, 7		96	10, 15 p. m.	503, 1		95
10, 30 p. m.	503, 0		95	10, 30 p m.	503, 4		95
10, 45 p. m.	503, 0		95	10, 45 p. m.	503, 9		95
11 p. m.	503, 2	+0, 64	95	11 p. m.	504, 5	+ 0, 90	95
11, 15 p. m.	503, 4		95	11, 15 p. m.	504, 7		95
11, 30 p. m.	503, 6		95	11, 30 p. m.	504, 9		91
11, 45 p. m.	503, 7		95	11, 45 p. m.	505, 7		95
12 p. m.	503, 8	+ 0, 76	95	12 p. m.	505, 9	+ 1, 18	95
12, 15 p. m.	504, 1		91	12, 15 p. m.	506, 1		95
12, 30 p. m.	504, 2		91	12, 30 p. m.	506, 3		95
12, 45 p. m.	504, 3		91	12, 45 p. m.	506, 5		95
1 p. m.	504, 5	+ 0, 86	96	1 a. m.	506, 7	+ 1, 34	95
1, 15 p. m.	504, 7		91	1, 15 a. m.	506, 9		95
1, 30 p. m.	505, 1		82	1, 30 a. m.	507, 2		95
1, 45 p. m.	505, 1		91	1, 45 a. m.	507, 3		95
2, p. m.	505, 1	+ 1, 02	95	2 a. m.	507, 7	+ 1, 54	95
2, 15 p. m.	505, 1		95	2, 15 a. m.	508, 0		95
2, 30 p. m.	505, 1		96	2, 30 a. m.	508, 1		95
2, 45 p. m.	505, 3		95	2, 45 a. m.	508, 1		95
3 p. m.	505, 3	+ 1, 06	95	3 a. m.	508, 7	+ 1, 74	90
3, 15 p. m.	505, 3		95	3, 15 a. m.	508, 7		90
3, 30 p. m.	505, 3		95	3, 30 a. m.	508, 8		90
3, 45 p. m.	505, 4		95	3, 45 a. m.	508, 9		90
4 p. m.	505, 4	+ 1, 08	95	4 a. m.	509, 0	+ 1, 80	90
4, 15 p. m.	505, 5		95	4, 15 a. m.	509, 1		90
4, 30 p. m.	505, 5		95	4, 30 a. m.	509, 3		90
4, 45 p. m.	505, 5		95	4, 45 a. m.	509, 3		90
5 p. m.	505, 4	+ 1, 08	95	5 a. m.	509, 3	+ 1, 86	91
5, 15 p. m.	505, 4		95	5, 15 a. m.	509, 3		90
5, 30 p. m.	505, 4		95	5, 30 a. m.	509, 7		90
5, 45 p. m.	505, 5		95	5, 45 a. m.	509, 9		90
6 p. m.	505, 5	+ 1, 10	95	6, a. m.	509, 9	+ 1, 98	90
6, 15 p. m.	505, 6		95	6, 15 a. m.	509, 9		90
6, 30 p. m.	505, 7		95	6, 30 a. m.	509, 9		95
6, 45 p. m.	505, 6		95	6, 45 a. m.	509, 9		95
7 p. m.	505, 2	+ 1, 04	95	7 a. m.	510, 1	+ 2, 02	95
7, 15 p. m.	504, 8		96	7.15 a. m.	509, 3		91
7, 30 p. m.	504, 7		96	7.30 a. m.	508, 9		91
7, 45 p. m.	504, 6		96	7, 45 a. m.	508, 1		84
8 p. m.	504, 5	+ 0, 90	96	8 a. m.	507, 4	+ 1, 48	83
8, 15 a. m.	504, 2		96	8, 15 a. m.	507, 4		91
8, 30 a. m.	504, 0		91	8, 30 a. m.	506, 9		91
8, 45 a. m.	503, 9		91	8, 45 a. m.	506, 3		91
9 a. m.	502, 9	+ 0, 58	92	9 a. m.	505, 6	+ 1, 12	96
9, 15 a. m.	502, 7		84	9, 15 a. m.	505, 1		96
9, 30 a. m.	500, 9		92	9, 30 a. m.	504, 8		96
9, 45 a. m.	500, 5		84	9, 45 a. m.	504, 5		96
10 a. m.	500, 2	+ 0, 04	84	10 a. m.	503, 7	+ 0, 74	96
10, 15 a. m.	499, 5		84	10, 15 a. m.	503, 4		96
10, 30 a. m.	499, 1		84	10, 30 a. m.	502, 9		96
10, 45 a. m.	498, 4		92	10, 45 a. m.	501, 9		96

HOURLY RECORDS OF VARIATIONS IN WEIGHT OF CACAO BEANS AND VARIATIONS OF RELATIVE HUMIDITY—Continued

Fermented Cacao Sample No. 3				Unfermented Cacao Sample No. 5			
Hour	Weight gr.	Per cent variations	Relative humid.	Hour	Weight gr.	Per cent variations	Relative humid.
11 a. m....	497,4	— 0,52	92	11 a. m..	501,0	+ 0,20	96
11,15 a. m....	497,2	....	92	11,15 a. m..	500.3	....	96
11,30 a. m....	496,0	....	92	11,30 a. m..	500.2	....	96
11,45 a. m....	495,3	....	92	11,45 a. m..	499,3	....	92
12 a. m....	494,8	— 1,04	92	12 a. m..	498,9	— 0,22	96
12,15 p. m....	494,0	....	92	12,15 p. m..	498,4	....	93
12,30 p. m....	493,9	....	92	12,30 p. m..	497,9	....	96
12,45 a. m....	493,8	....	92	12,45 p. m..	497,3	....	96
1 p. m.....	493,7	— 1,26	92	1 p. m...	496,9	— 0,62	93
1,15 p. m.....	492,9	....	92	1,15 p. m...	496,9	....	96
1,30 p. m.....	492,4	....	92	1,30 p. m...	496,7	....	96
1,45 p. m.....	492,2	....	92	1,45 p. m...	496,7	....	93
2 p. m.....	492,0	— 1,60	85	2 p. m...	496,5	— 0,70	93
2,15 p. m.....	491,7	....	85	2,15 p. m...	496,5	....	96
2,30 p. m.....	491,3	....	85	2,30 p. m...	496,5	....	96
2,45 p. m.....	491,2	....	85	2,45 p. m...	496,5	....	96
3 p. m.....	491.1	— 1,78	85	3 p. m...	496,7	— 0,66	96
3,15 p. m.....	491,2	....	85	3,15 p. m...	497,1	....	96
3,30 p. m.....	491,2	....	85	3,30 p. m...	497,1	....	96
3,45 p. m.....	491,2	....	85	3,45 p. m...	497,1	....	96
4 p. m.....	491,3	— 1,74	85	4 p. m...	497,2	— 0,56	96
4,15 p. m.....	491,8	....	85	4,15 p. m...	497,3	....	96
4,30 p. m.....	491,9	....	85	4,30 p. m...	497,0	....	96
4,45 p. m.....	492,0	....	85	4,45 p. m...	497,4	....	96
5 p. m.....	492,0	— 1,60	88	5 p. m...	497,4	— 0,52	96
5,15 p. m.....	492,2	....	88	5,15 p. m...	497,5	....	96
5,30 p. m.....	492,3	....	88	5,30 p. m...	497,6	....	96
5,45 p. m.....	492,5	....	88	5,45 p. m...	497,8	....	91
6 p. m.....	492,8	— 1,44	88	6, p. m...	498,0	— 0,40	91

These results are graphically expressed in the diagram of plate XXXII.

DETERMINATION OF CRITICAL MOISTURE POINT FOR MOULDING

Small random samples of cacao beans, both fermented and unfermented (taken from the samples N. 3 and 5), composed of 20 seeds each, were selected. A mixture of conidia and spores of *Aspergillus niger, A. fumigatus, A. glaucus, A. flavius, Rhizopus nigricans, R. arrhizus* and *Mucor mucedo* from fresh carrot agar cultures was prepared and kept dry in a desiccator. Each sample of cacao was enclosed in a common glass cup, and inoculated by dusting (using a small brush) with the mixture of conidia, then covered with a photographic glass plate. Furthermore, in order to regulate the amount of moisture of the atmosphere of the glass cup and to equilibrate the moisture content of the beans with the moisture of enclosed air, a 20 c.c. beaker containing a definite saline solution was inclosed in the glass cup.* The plate glass cover was sealed to the cup with paraffin.

* For references on the method for maintaining constant humidity, see Spencer, H. M. Laboratory methods or maintaining constant humidity.

The following table shows the saline compounds used and the respective concentration of each. As the experiment was made in the Laboratory, and of course, not at a constant temperature, the relative humidity oscileated between two extreme limits. Maximum, minimum and average relative humidity was approximately calculated from Spencer curves or tables.

CONCENTRATION OF THE SOLUTIONS AND RELATIVE HUMIDITY

Salts	Concentration of solution	32 °C. % humidity (aproxim.)	24 °C. % humidity (aproxim.)	28 °C. % humidity (aproxim.)
H_2O Distilled (test)	....	100	100	100
H_2SO_4 concentrated (test)	....	Almost 0	Almost 0	Almost 0
$Na_2CO_3.10\ H_2O$	Saturated	81	87	84
$Na_2SO_4.10\ H_2O$	Saturated	88	92	90
Na Cl and KNO_3	Saturated	34	30	32
$(NH_4)_2SO_4$	Saturated	82	88	81
NaOH	N	80	81	80
NaOH	5N	80	81	81
NaOH	10N	84	85	84
NaOH	15N	84	85	85
NH_4Cl	Saturated	80	79	79
NaCl and $KClO_3$	Saturated	34	36	35
$KHSO_4$	Saturated	83	85	84
NaCl, KNO^3 and $NaNO_3$	Saturated	28	30	29
$BaCl_2.2\ H_2O$	Saturated	86	88	87
$ZnSO_4.7\ H_2O$	Saturated	88	90	89
$Na_2Cr_2O7.2\ H_2O$	Saturated	48	52	50

The experience begun November 13 and ceased February 15 of the subsequent year. The results were as follows:

CACAO MOULDING AS RELATED TO RELATIVE HUMIDITY

First development of moulds	Days from the beginning	Average relative humidity	Solution of
Fermented cacao beans			
November 21	8	90	Na_2SO_4
November 23	10	84	Na_2CO_3
November 23	10	100	H_2O
November 25	12	87	$BaCl_2$
November 26	13	81	$(NH_4)_2SO_4$
November 26	13	85	NaOH. 15N
November 27	14	84	NaOH. 10N
November 28	15	84	$KHSO_4$
November 28	15	89	$ZnSO_4$
November 29	16	81	NaOH. 5N
November 29	16	80	NaOH N
November 29	16	79	NH_4Cl.
Unfermented cacao beans			
November 19	6	100	H^2O
November 20	7	90	Na_2SO_4
November 20	7	89	$ZnSO_4$
November 21	8	85	NaOH. 15N
November 21	8	84	NaOH. 10N
November 21	8	84	$KHSO_4$
November 22	9	87	$BaCl_2$
November 22	9	81	$(NH_4)_2SO_4$
November 23	10	81	NaOH. 5N
November 23	10	80	NaOH. N
November 23	10	79	NH_4Cl
November 24	11	84	Na_2CO_3

DISCUSSION OF THE RESULTS AND CONCLUSIONS

The results of the experiments may be summarized as follow:

(1) The normal moisture content of fermented and unfermented cacao beans varies from 14 to 21 per cent, based on 9 determinations of 9 samples, with a general average of 19 per cent. Moisture content of unfermented cacao beans is higher than the fermented cacao beans, being respectively, 19 and 15 per cent. Also, the moisture content is very variable in different samples.

(2) Also the specific weight varies from a minimum of 0.883 to a maximum of 0.991; this difference is partially related, in our opinion, to the different moisture content. The general average based on 40 determinations on 4 samples is 0.934, but the average of unfermented cacao is slightly higher than in fermented cacao: respectively 0.890 and 0.887.

(3) The size of fermented and unfermented cacao beans is almost the same, the general average being 20 mm. in length, 12 mm. broad and 7 mm. thick.

(4) The capacity of imbibition of cacao beans when immersed in distilled water at 40° C. is about 18 per cent of the initial weight, but varies from 15 per cent (fermented cacao beans) to 20 per cent (unfermented cacao beans). The imbibition is complete during the first 24 hours of immersion.

(5) The capacity of imbibition of cacao beans when exposed to saturated water vapor at room temperature is about 1.10 per cent of the initial weight; these results were obtained in a closed room during five days, at room temperature. Daily absorption is extremely irregular, varying from 2.38 per cent to 0 per cent. The total absorption during the five days is as irregular as the preceding, oscillating from a minimum of 0.56 per cent to a maximum of 2.77 per cent. The average total absorption of unfermented beans (1.57 per cent) is greater than the average of fermented beans (0.56 per cent).

(6) The effect of drying at different temperatures ranging from 40° C. to 100° C. to the absorption of water vapor, when dried cacao beans are exposed to saturated water vapor during ten days, is very clear on fermented cacao beans. The absorption of water vapor is inversely proportional to the temperature of drying, being maximum at the lowest temperature (40° C. and 1.10 per cent of increase in weight) and minimum to the highest temperature (of 80° C., 90°C.,

and 100° C. respectively 0.42, 0.43 and 0.44 per cent). The best temperature for desiccation of fermented cacao beans, as related to the water vapor absorption, is 80° C. On the contrary, the desiccation of unfermented cacao at different temperatures is apparently without influence on the water absorption, the course of increase in weight being very irregular.

(7) The loss of moisture of cacao beans exposed to direct sunshine during 11 hours (7 hours during the first day, and 4 hours during the second) is as irregular as the imbibition of the seeds when exposed to saturated water vapors. In a general way, it is strongest during the first hour, and gradually but irregularly decreased during the following four hours, falling during the 6th and 7th hours. From the 8th to the 11th hour the loss in weight is almost uniform. The general average of loss in weight is 2.03 per cent, but varying from 3.66 per cent to 1.31 per cent. The desiccation is highest in unfermented cacao beans (average 2.27 per cent) than in fermented cacao beans (average 1.78 per cent), according the greater amount of moisture of unfermented seeds as related to fermented seeds.

(8) The average daily weight of samples of fermented and unfermented cacao, recorded during 100 days, is apparently without direct relation to the average daily relative humidity. It is probable that the relation is not simple and exclusive, and other factors influence the variation in weight of cacao beans, as atmospheric pressure, solar irradiation, and so on. These results are confirmed by the record of hourly variation in weight of fermented and unfermented cacao and relative humidity of the atmosphere.

(9) A 24 hours record of samples of cacao beans, both fermented and unfermented, exposed to the free air, taken at the interval of 15 minutes showed a marked variation of increase and loss in weight of fermented or unfermented beans. Moisture absorption of fermented cacao oscillates between 1.10 per cent and 1.78 per cent, with a total range of 2.88 per cent. Moisture absorption of unfermented cacao varies between 2.02 per cent to 0.70 per cent, with a total range of 2.72 per cent. In spite of the fact that the total range of the weight is almost the same in both samples, fermented cacao lost 0.68 per cent in weight, and unfermented cacao increased 1.38 per cent in weight.

The abundant literature on cacao problems, shows that the most important determinations of moisture content of beans and its variations were made in West Africa on unfermented cacao of Accra

type, by Schwarz (**26**). This author found a moisture content varying from 7.16 per cent to 15.32 per cent. Selecting the beans on the base of dryness, he subdivides them into: (1) beans quite pliable in the shell, (2) beans in which the nib was of a cheesy consistency and presented a wet looking surface when cut, and (3) beans which appeared to be fairly dry. Their respective average for three determinations each were: (1) 14.50, (2) 11.33, (3) 8.15. These results agree well with the results obtained on Santo Domingo cacao. The same author performed three experiments on the relationship between humidity and moisture content of cut and shelled cacao beans, weighing a few seeds as well as bags of cocoa. He demonstrated that cut cacao readily absorbed moisture, and that the amount absorbed varied with the humidity. Percentage of moisture varies from 6 per cent to 14.98 per cent. Since the percentage of absorbed moisture agrees with our results, we cannot demonstrate the relationship between moisture of the air and moisture of the cacao. Shelled beans absorbed from 1.32 per cent to 3.96 per cent of moisture. According Schwarz's results, the maximum increase in weight of cacao in burlap bag was only 0.47 per cent. Finally, according the same author, some data obtained from the Gold Coast Department of Agriculture indicated that beans containing in excess of 10 per cent of moisture are prone to mould. From a general point of view, Accra cacao offers a noteworthy analogy with Sánchez cacao, but a most complete picture of moisture in Gold Coast cocoa is desirable for the purpose of comparison.

One of the most important determination is the critical moisture point. The writer ascertained that a relative humidity of 79 per cent permits the development of moulds after 16 days of incubation on fermented cacao, the minimum time required being 8 days at a relative humidity of 90 per cent. On unfermented cacao, the minimum of moisture required is 79 per cent, the incubation during 10 days, and the minimum time 6 days at 100 per cent of relative humidity. The writer does not express the critical moisture point as moisture content of the beans, but surely the moisture is greater than 10 per cent, as indicated in Cold Coast.

These results may be favorably compared with the experiments performed in the Philippines on moulding of copra by Lava (**17**). He found that the critical moisture point at room temperature is 81 per cent, and the period of incubation from 7 to 21 days.

No continuous series of records of relative humidity of Santo

Domingo are available to date, but records for scattered years for Santo Domingo City, Haina, Moca, Santiago, Puerto Plata and Sánchez. The general average is comprised between 65 and 70 per cent, with two minima 60–65 per cent (December to March, and June to August) and two maxima of 70–75 per cent (April–May, and September–November). From 12 to 4 o'clock, during the night, the percentage of relative humidity very rarely drops to 80 per cent, at sea level, and it is surely higher at 600 meter elevation, which is limit of cacao cultivation in Santo Domingo.

The writer concludes that both climatic and metereologic conditions in Santo Domingo, are very frequently favorable to the development of moulds on cacao beans, taking in consideration the commonly very bad preparation of cacao by farmers, as explained in the latter part of this paper.

PREVENTION OF MOULDING OF CACAO

The problem of the prevention of moulding of cacao must be considered under two aspect: (1) the most general and most important, concerning a better preparation of cacao, chiefly from the standpoint of drying, (2) the more specialized, concerning an appropriate storage on farms, villages and depots at the shipping ports, and in steamship holds.

The first aspect of the problem, or the defects in the preparation of cacao, is, more or less, the same in all the larger cacao-countries of the world. In a previous Report (7), the writer examined the defects common in Santo Domingo, of which the most important are:

(1) The almost general tendency to produce unfermented cacao which is more susceptible to moulding than the fermented cacao.

(2) The very common practice of mixing cacao beans from healthy and mature pods with beans from diseased, over ripe and immature pods which have the tendency to become moldy.

(3) Buying and selling cacao beans on wet or semidry basis, and in a general way, incomplete or imperfect or inadequate drying of cacao. Many causes co-operate to this tendency, as, e. g., indigence of small farmers, imperfect equipment of farmers, keen competition among brokers, lack of attention in drying, inadequate protection and equipment of brokers, storekeepers, exporters, and others.

(4) Inadequate legislation, inspection and grading before and after storage.

The second aspect of the problem, or the conservation of cacao in stores or depots or steamship holds at a satisfactory percentage of humidity could be examined, if necessary, under the basis of Lava's proposition for prevention of copra mouiding, using solid NaCl or solid $NaNO_3$ which maintained, at the temperature of 26–33°C., a relative humidity of about 73 per cent. $CaCl_2$ or CaO must be used if a greater reduction of humidity is desired. The use of these substances is economical, since after the complete or partial solution, they can be easily recovered or, in the case of CaO, used as calcium hydroxide. The problem of high humidity in the holds of the vessels and increase of moulding of cacao beans during the shipment must be studied.

In our opinion, the gradual elimination of the unsatisfactory conditions listed will be the best method to improve the Dominican cacao.

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SUMMARY

Experiments on the environmental conditions influencing the moulding of fermented and unfermented Dominican cacao beans were carried.

IV. TESTS FOR ENZYMES OF CACAO

The knowledge of the enzymes of cacao beans, both in fresh and dry seeds (fermented and unfermented), is the basis for the understanding of the mechanism and effect of the fermentation. Scattered notices on this subject are found in the literature of cacao technology, but the first complete study was performed in the Philippine Island by Brill (1). This investigation has been undertaken for a comparison with Brill's results, a few of which are different from the results obtained by previous investigators, as well as for testing enzymes not previously considered.

METHOD OF STUDY

Four series of experiments were carried out, using unselected

Dominican cacao (Sánchez type), harvested in Moca and prepared in the National Agronomic Station, namely: (1) fresh cacao beans with surrounding pulp, (2) fresh and clean cacao beans without the pulp, (3) clean fermented cacao beans, prepared by fermenting the seeds during four days at the temperature of the laboratory (20–30°.C) and then drying, (4) clean unfermented cacao beans, prepared by drying the seeds after carefully washing.

The method used was almost the same as the method employed by Brill: a 10 per cent aqueous solution of ground seeds, standing six hours and then filtered through cloth, was mixed with 2 per cent (by volume) of toluene and 2 per cent of chloroform, both as antiseptic and as facilitating the exosmose of the enzymes.

Each experiment was repeated at least three times, and more, if necessary, until a confirmation of positive or negative results was obtained.

Saccharase. 10 c.c. of water, 10 c.c. of cacao bean extract, 10 c.c. of 40 per cent cane-sugar solution, 3 drops of very diluted chloridric acid (pH of the mixture 4.6), standing 48 hours at 40° C., and testing with Fehling solution.

(1) Fresh beans and slime: strongly positive.
(2) Fresh clean beans: positive.
(3) Fermented beans: negative.
(4) Unfermented beans: slightly positive.
(5) Test: negative.

Maltase. As in the preceding, but using 10 c.c. of 20 per cent maltose solution (pH of the mixture acidized: 4.2).

(1) Fresh beans and slime: negative.
(2) Fresh clean beans: negative.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

As in the preceding, but using bean extract obtained by 10 days of maceration in thermostate at 40°C. (pH of the mixture, acidized: 4.0).

(1) Fresh beans and slime: slightly positive.
(2) Fresh clean beans: positive.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

Lactase. As in the preceding, using a 20 per cent lactose solution (pH of the mixture, acidized: 4.4).

(1) Fresh beans and slime: negative.
(2) Fresh clean beans: negative.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

As in the receding, but after 10 days of maceration (see above); (pH of the mixture, acidized: 5.0).

(1) Fresh beans and slime: negative.
(2) Fresh clean beans: negative.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

Trehalase. As in the preceding (pH of the mixture, acidized: 4.4).

(1) Fresh beans and slime: negative.
(2) Fresh clean beans: negative.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

Melibiase. As in the preceding (pH of the mixture acidized: 4.8).

(1) Fresh beans and slime: negative.
(2) Fresh clean beans: negative.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

Amylase. 40 c.c. of soluble starch solution (1 per cent), 10 c.c. of bean extract, standing 48 hours at 40°C., testing the presence of reducing sugars with Fehling solution.

(1) Fresh beans and slime: strongly positive.
(2) Fresh clean beans: slightly positive.
(3) Fermented beans: negative.
(4) Unfermented beans: slightly positive.
(5) Test: negative.

Dextrinase. As in the preceding, but testing the presence of dextrines with Lugol solution.

(1) Fresh beans and slime: yellowish.
(2) Fresh clean beans: reddish.
(3) Fermented beans: violet-bluish.
(4) Unfermented beans: reddish.
(5) Test: violet-bluish.

Pectinase. 25 c.c. of bean extract, 5 gm. of pectine, freshly prepared from carrots (Bertrand and Mallevre method, as referred by Calmette, Negre and Bouquet: Man. techn. de Microbiol. et Sérol., II édit., p. 168. Paris, 1926), testing the presence of reducing sugars with Fehling solution, after 48 hours at 40°C.

(1) Fresh beans and slime: negative.
(2) Fresh clean beans: negative.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

Cellulase. 25 c.c. of bean extract, 5 gm. of stripes of ashless filter paper. After 48 hours of incubation at 40° C., the paper is washed, dried and weighed.

(1) Fresh beans and slime: negative.
(2) Fresh clean beans: negative.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

Emulsin. 10 c.c. of bean extract, 10 c.c. of amygdalin (2 per cent solution), standing 48 hours at 40°C., and testing the presence of cyanhidric gas with picro-sodic paper in a corked Erlenmeyer.

(1) Fresh beans and slime: pinkish.
(2) Fresh clean beans: pinkish.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

As above, but testing with 10 drops of freshly prepared $Fe\ SO_4$ solution (3 per cent), one drop of $Fe\ Cl_3$ (1 per cent), mixing thoroughly, adding NaOH solution (10 per cent) and dissolving the precipitate with H_2SO_4 solution (10 per cent).

(1) Fresh beans and slime: light Prussian-blue color.
(2) Fresh clean beans: slight Prussian-blue color.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

Protease. 5 gm. of coagulated egg albumine, 25 c.c. of bean extract, for 10 hours at 40°C., testing the loss in weight of albumine cylinders (Mett method, Arch. Anat. und Physiol., Physiol. Abth., *68:* 94). Liquid media acidified with a few drops of very diluted chloridric acid (pH 3.8).

(1) Fresh beans and slime: negative (loss gm. 0,003).
(2) Fresh clean beans: negative (loss gm. 0,008).
(3) Fermented beans: negative (loss gm. 0,004).
(4) Unfermented beans: negative (loss gm. 0,008).
(5) Test: negative (loss gm. 0,005).

Tryptase. One cubic centimeter of 30 per cent solution of gelatine in thymol solution (0,1 per cent) is distributed in each test tube of 5 mm. in diameter, being previously alcalinized with 2 per cent of NaOh N/10, adding 1 c.c. of bean extract to each test tube. After 48 hours at 30°C., the height of the cylinder of gelatine is measured (Fermi method, as referred to De Rossi, Microbic. agr. e tecn. 204.1927).

(1) Fresh beans and slime: negative.
(2) Fresh clean beans: negative.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

Peptase. 10 c.c. of egg albumen solution (one egg albumen in 100 c.c. of water), 10 c.c. of bean extract, for 48 hours at 40°C (pH of the solution:

6.2). Acidity of dissociated amynoacid is titrated with KOH 1/10 N(Sörensen's tritimetric method, as referred in De Rossi, 1. c., p. 205).

(1) Fresh beans with slime: c.c. 1, 0.

(2) Fresh clean beans: c.c. 0,9.

(3) Fermented beans: c.c. 0,6.

(4) Unfermented beans: c.c. 0,8.

(5) Test: c.c. 0,6.

20 c.c. of egg albumen solution, prepared as above, 10 c.c. of seed extract, standing 48 hours at 40°C. Indole test performed by Goré modification of the technic of Ehrlich-Böhme (as referred by the Comm. on Bact. Techn., Soc. Amer. Bacteriol. Manual meth. pure culture study of Bacteria, p. VI/14. 1930).

(1) Fresh beans with slime: negative.

(2) Fresh clean beans: negative.

(3) Fermented beans: negative.

(4) Unfermented beans: negative.

(5) Test: negative.

20 c.c. of Bactopeptone solution (2 per cent), 10 c.c. of bean extract, for 48 hours at 40°C. Indole tested as above (pH=6, 2).

(1) Free beans with slime: negative.

(2) Fresh clean beans: negative.

(3) Fermented beans: negative.

(4) Unfermented beans: negative.

(5) Test: negative.

Amynoacidase. 20 c.c. of asparagine (2 per cent solution), 10 c.c. of been extract, for 48 hours at 40° C., testing the alcalinity with KOH N/10.

(1) Fresh beans with slime: c.c. 2, 2.

(2) Fresh cleans beans: c.c. 2, 3.

(3) Fermented beans: c.c. 1, 6.

(4) Unfermented beans: c.c. 2, 0.

(5) Test: c.c. 1, 5.

Lipase. 10 c.c. of water, 10 c.c. of bean extract, 1 c.c. on pure olive oil, 1 drop of diluted acetic acid, for 48 hours at 40°C., testing the acidity with NaOH N/10.

(1) Fresh beans with slime: c.c. 2, 2.

(2) Fresh clean beans: c.c. 1, 7.

(3) Fermented beans: c.c. 2, 91.

(4) Unfermented beans: 5, 9.

(5) Test: c.c. 2, 1.

Glycerophosphatase. 10 c.c. of water, 10 c.c of bean extract, 50 c.c. of 2 per cent solution of sodic glycerophosphate, 48 hours at 40° C. (pH = 5, 8), testing the presence of soluble phosphoric acid with ammonium molybdate solution.

(1) Fresh beans with slime: slight yellow coloration.

(2) Fresh clean beans: slight yellow coloration.

(3) Fermented beans: negative.

(4) Unfermented beans: negative.

(5) Test: negative.

Fitase. 20 c.c. of bean extract, 30 c.c. of 2 per cent solution of fitine, 48 hours at 40°C., (pH=6.2), testing the presence of soluble phosphoric acid with ammonium molybdate solution.

(1) Fresh beans with slime: slight yellow coloration.
(2) Fresh clean beans: slight yellow coloration.
(3) Fermented beans: negative.
(4) Unfermented beans: negative.
(5) Test: negative.

Oxidase and peroxidase 20 c.c. of seed extract, 1 c.c. of alcoholic tincture of guaiacum (10 per cent), the color being observed after ½ hour, 2 hours, 12 hours and 24 hours of thermostation at 40°C.

(1) Fresh beans with slime: light red; red; dull read; dull red.
(2) Fresh clean beans: pinkish; red-pinkish; red; red.
(3) Fermented beans: no change; pinkish; red; pinkish.
(5) Unfermented beans: pinkish; red-pinkish; red; red.
(5) Test: no change.

5 c.c. of bean extract, 1 c.c. of benzidine solution (0.5 per cent) and 5 drops of H_2O_2, 2 hours at 40°C.

(1) Fresh beans with slime: violet-bluish.
(2) Fresh clean beans: light violet-blue.
(3) Fermented beans: very light violet-blue.
(4) Unfermented beans: violet-blue.
(5) Test: unchanged.

5 c.c. of bean extract, 1 c.c. of solution of acid pyrogallic (2 per cent), 5 drops of H_2O_2, after 24 hours at 40°C.

(1) Fresh beans with slime: duty yellow with precipitate.
(2) Fresh clean beans: dirty yellow with precipitate.
(3) Fermented beans: very light yellow.
(4) Unfermented beans: dirty yellow.
(5) Test: unchanged.

Catalase. 5 c.c. of bean extract 50 c.c. of neutralized H_2O_2 (pH=6.8.) 1 per cent solution, measuring the O developed, using a common calcimeter, after 24 hours at the temperature of Laboratory (24–30°C.).

(1) Fresh beans with slime: 31, 1 c.c. of oxigen.
(2) Fresh clean beans: 29, 2 c.c. of oxigen.
(3) Fermented beans: 2, 7 c.c. of oxigen.
(4) Unfermented beans: 11, 8 c.c. of oxigen.
(5) Test: 0, 8 c.c. of oxigen.

Philotion. 10 c.c. of bean extract, 2 gm. of precipitated sulphur contained in closed Erlenmeyer flask in presence of stripes of lead acetate paper, after 24 hours at 40°C.

(1) Fresh beans with slime: very light brown color.
(2) Fresh clean beans: very light brown color.
(3) Fermented beans: no change.
(4) Unfermented beans: very light brown color.
(5) Test: no change.

Reductase. 10 c.c. of bean extract, 10 c.c. of water, 1 c.c. of methylene blue solution at 1 per cent, after 48 hours at 40°C.

(1) Fresh beans with slime: slightly decolorized.
(2) Fresh clean beans: no change.
(3) Fermented beans: no change.
(4) Unfermented beans: no change.
(5) Test: no change.

DISCUSSION OF THE RESULTS

The results of our experiences, as compared with the tests performed by Brill, may be summarized as follows:

Enzyme (1)	Brill's experiments					Author experiments				
	Pulp	Heated pulp	Fresh clean seeds	Heated fresh clean seeds	Fermented seeds	Heated fermented seeds	Fresh seeds with slime	Fresh clean seeds	Fermented seeds	Unfermented seeds
A-HYDROLYZING ENZYMES										
a-DECOMPOSING CARBOHYDRATES										
1-Saccharase (invertase)	P	P	N	N	P	P	P	P	N	P
2-Maltase	N	N	N	N	N	N	P	P	N	N
3-Lactase	.....	.....	.....	.....	.....	.....	N	N	N	N
4-Trehase	.....	.....	.....	.....	.....	.....	N	N	N	N
5-Melibiase	.....	.....	.....	.....	.....	.....	N	N	N	N
6-Raffinase	P	P	P	P	P	P	.....	.....	.....	.....
7-Amylase (diastase) (2)	N	N	N	N	P	P	P	P	N	P
8-Dextrinase (3)	N	N	N	N	?	N	P	N	N	N
9-Inulase	N	N	N	N	N	N	.....	.....	.....	.....
10-Pectinase	.....	.....	.....	.....	.....	.....	N	N	N	N
11-Cellulase	.....	.....	.....	.....	.....	.....	N	N	N	N
b-DECOMPOSING GLUCOSIDES										
1-Emulsin	N	N	N	N	N	N	P	P	N	?
c-DECOMPOSING PROTEIC SUBST.										
1-Protease	.....	.....	.....	.....	.....	.....	N	N	N	N
2-Tryptase	.....	.....	.....	.....	.....	.....	N	N	N	N
3-Peptase (indole test)	.....	.....	.....	.....	.....	.....	N	N	N	N
4-Albuminase (tryptophane test)	?	N	N	N	N	N	.....	.....	.....	.....
5-Protease (tryptophane test)	P	N	N	N	N	N	.....	.....	.....	.....
6-Amynoacidase	.....	.....	.....	.....	.....	.....	?	?	N	?
d-DECOMPOSING FAT SUBSTANCES										
1-Lipase	N	N	N	N	N	N	N	N	N	P
e-DECOMPOSING ETHER. COMP. PHOSPHORIC ACID										
1-Glycerophosphatase	.....	.....	.....	.....	.....	.....	P	P	N	N
2-Fitase	.....	.....	.....	.....	.....	.....	P	P	N	N
B-OXIDING AND REDUCING ENZYMES										
1-Oxidases	P	N	P	N	P	N	P	P	P	P
2-Peroxidases	.....	.....	.....	.....	.....	.....	P	P	P/?	P
3-Catalase	.....	.....	.....	.....	.....	.....	P	P	?	P
4-Philothion	.....	.....	.....	.....	.....	.....	P	P	N	P
5-Reductase	P	P	P	P	P	P	P	N	N	N

(1)—N-Negative results; P-Positive results; ?-Doubtful results.
(2)—The name of enzymes enclosed in the brackets, are used in the Brill's paper.
(3)—In the study of Brill, the dextrinase is comprised in the test for diastase.

The hydrolyzation of the saccharose is a controversial point. According Brill (1), fresh clean cacao beans do not hydrolyze this sugar, while, in our experience, the enzyme is found on seeds with slime, clean seeds and dried cacao beans, but not in the fermented cacao. Different results can be explained by the different environmental conditions of the tests, such as concentration of the sugar solution, hydrogen-ions concentration, etc.

The tests for maltase in the Philippine cacao were negative, and Brill affirmed that "this appears to be one of the rarer cases of diastases unaccompanied by maltase". Our first test, repeating, more or less, the conditions of the tests performed by Brill showed negative results. A second series of tests, varying the duration of

the incubation (ten days instead of two days), showed positive results only in fermented and unfermented cacao beans. It is well known that the maltase is an endoenzyme not easily extracted from the plant cell, and only from dried material, after a long maceration.

Amylase (an enzyme hydrolyzing starch to dextrines) is not present in fermented beans only, but dextrinase (an enzyme hydrolyzing dextrines to maltose) was in beans without slime, fermented and unfermented cacao. These results are in contrast with Brill's results and are confusing.

In our experiment, the presence of amygdaline was demonstrated, at least in fresh seeds (with and without slime), in accordance with the results of Sack (cfr. H. Smith. Ferment of cacao, p. 148. London 1913), but in disagreement with Brill's results.

Of the enzymes hydrolyzing proteic substances, or its derivates, the presence of the amynoacidase is doubtful; hydrolizing enzymes, both in acid and alcaline media, are absent. These results are in partial disagreement with Brill's tests.

Lipase is present only in dry unfermented seeds. Glicerophosphatase and fitase are secreted by fresh seeds.

Oxiding and peroxiding enzymes are contained in fresh and dry cacao beans, as well as, in part, the enzyme transforming sulphur in sulfuretted hydrogen. Only fresh seeds with slime contain reductase. Brill found reductase in pulp, fresh, and fermented seed, also heated.

CONCLUSIONS

From the results of these investigations, definite conclusions cannot be drawn without a deep knowledge of organic compounds contained in slime, fresh fermented and unfermented cacao beans, as well as without the study of enzymatic activities of cacao-fermenting organisms. Unfortunately, these observations are fragmentary and rather incomplete.

Of twenty-two tested enzymes, only oxiding and peroxiding enzymes are universally diffused on different kinds of cacao beans. Fresh seeds with slime are of the amplest range of enzymatic activity (13 enzymes); fresh clean seeds (without slime) contain 11 enzymes, tests for dextrinase and reductase being negative. Fermented dry seeds contain 9 enzymes, the range of the enzymatic activities being limited to the invertase, diastase, lipase, oxiding and peroxiding enzymes, including the doubtful presence of the amynoacidase and emulsin. Positive test for the presence of a

lipolytic enzyme, (splitting fatty substances into glycerol and fatty acids) ascertained only in unfermented seeds should be particularly mentioned, as related with the rank odor of some Dominican unfermented samples of cacao. The presence of the lipase must be confirmed testing fatty substances composed of higher fatty acids as sterinolipoids, recently obtained on cacao beans. In spite of the fact that the presence of a relatively large amount of fats in cacao beans indirectly confirms the necessary presence of a lipolytic enzyme, this test is not very sure for the presence of the glicerophosphatase and fitase. If glicerophosphatids and fitine are present in cacao seeds, the acidity of the test on fatty substances should be derivated, at least in part, from the hydrolyse of esters of phosphoric acid.

Fermented cacao lacks almost totally of enzymatical activities; only three enzymes were obtained, of which two are of doubtful presence. The only enzyme surely present is the oxidase, probably associated with the frequent blackening of old Dominican fermented and unfermented cacao. The poor enzymatic activity (from qualitative standpoint) of fermented cacao, as probably related with a greater stability of the seeds, could be favorably compared with the more active dried unfermented seeds. The fermented cacao bean is a truly dead seed, also from biochemical point of view, while an unfermented cacao bean is apt, under suitable conditions, to many biochemical changes resulting from its latent enzymatic activity.

SUMMARY

Twenty-two enzymes are tested on Dominican cacao. Fresh cacao beans with surrounding slime are the most active; fermented dry cacao beans are almost inactive. A lipase is probably present only in fermented cacao.

V. AN IMPROVED METHOD FOR THE DESICCATION OF CACAO BEANS

This method is based on the application of a distillation box for saline water, when exposed to the sunshine, for desiccation of fermented or unfermented cacao beans.

The principle of this apparatus, attributed to Charles Wilson, is well known: the saline water is contained in a metallic dish, enclosed in a flat wooden box; the top if formed by an inclined glass plate, and exposed to the direct sunshine. To each descent of temperature, the saturated water vapor enclosed in the box is condensed on the glass plate, and is collected in a bottle as distilled water.

This distilling box was used for the first time during the year 1872 for securing the supply of drinking water for the workers employed in the silver mines of Salinas, in the desert of Atacama (Chile), from a saline water containing 140 gr. of salt per liter. Using a series of Wilson's apparatus, with a glass surface of about 5,000 square meters, the production of distilled water was 23 metric tons per day.

The same apparatus was employed for many other uses, by Maurain and Brazier in Paris, Ginestous in Tunisy, Richard in Monac, Lozano in Spain, and others for the industrial drying of fish, fruit, distillation of alcohol, etc. This method and its application was described in detail by Richard (**24**) and by Lozano (**21**).

During the summer of 1929 I constructed an apparatus of about one square meter of glass surface, and during the months of August and September I experimented on the possibility of the using it in cacao bean drying. As these preliminary observations, under certain conditions, gave good results, I delayed the study of the practical application using a larger series of boxes to the summer of 1930, when the National Agronomic Station of Moca was closed.* For this reason the observation here referred to must be considered only as preliminary results, and the publication is made for the purpose of stimulating experiments on an industrial scale.

The structure of Wilson apparatus is explained by the sectional sketch of pl. XXXIII: ** *di* is the metallic dish containing the cacao beans; *wa* are the wooden walls; *pl* the glass plate; *mp* is a metal plate bended to Z shape, for the detention of drops; *co* is a gutter functioning as a water collector; *pi* indicate a small pipe line for conduction of the water to the bottle *bo* and four supports *fo*. One small door, *do* opening at the right side makes it possible to remove the metallis dish. The box is black painted and the joints (chiefly the glass plate joins) are sealed with sealing wax.

During many weeks, the temperature was recorded using a double-recording thermograph (air and soil thermograph) for simultaneous record of inside and outside temperature. In spite of the fact that the registrating pen for the box temperature was set so that the 0°C. line of the chart corresponded to 30°C., with a few

* A few experience on drying of fresh fruit, also made favorable results, using oranges, pawpaw, cashew fruits, *sapote* and *mamey*, but not completely good using star-apple, plantain and banana, also if cutted in small pieces.

** The figure is taken from Lozano paper.

exceptions, the maximum temperature was not included in the graphic. In other words, in a general ways, the maximum temperature is greater than 75°C., while the maximum is, more or less, the same as the free air, or slightly less. As exemplification, the two-hour temperature of the box and the temperature of the air is reported, from Wednesday September 25 to Sunday September 29; the graphic is illustrated in the plate XXXIV.

Day	Hour	Air temperature degrees C.	Averages degrees C.	Box temperature degrees C. (1)	Averages degrees C.
September 25	2 a. m.	24		24	
September 25	4 a. m.	23		23	
September 25	6 a. m.	22		35	
September 25	8 a. m.	21		55	
September 25	10 a. m.	28		75	
September 25	12 a. m.	31	25, 0	65	46, 0
September 25	2 p. m.	36		45	
September 25	4 p. m.	41		29	
September 25	6 p. m.	29		26	
September 25	8 p. m.	25		25	
September 25	10 p. m.	23		24	
September 25	12 p. m.	22	29, 0	23	29, 0
September 26	2 a. m.	22		22	
September 26	4 a. m.	21		21	
September 26	6 a. m.	21		38	
September 26	8 a. m.	23		55	
September 26	10 a. m.	28		80	
September 26	12 a. m.	32	24, 5	74	48, 0
September 26	2 p. m.	40		40	
September 26	4 p. m.	39		27	
September 26	6 p. m.	28		26	
September 26	8 p. m.	24		24	
September 26	10 p. m.	24		23	
September 26	12 a. m.	23	29, 5	22	27, 0
September 27	2 a. m.	21		23	
September 27	4 a. m.	21		24	
September 27	6 a. m.	23		27	
September 27	8 a. m.	23		37	
September 27	10 p. m.	24		22	
September 27	12 a. m.	29	23, 5	57	39, 0
September 27	2 p. m.	21		43	
September 27	4 p. m.	38		27	
September 27	6 p. m.	29		25	
September 27	8 p. m.	25		25	
September 27	10 p. m.	24		25	
September 27	12 p. m.	24	27, 0	25	26, 0
September 28	2 a. m.	24		25	
September 28	4 a. m.	24		24	
September 28	6 a. m.	23		37	
September 28	8 a. m.	24		58	
September 28	10 a. m.	28		77	
September 28	12 a. m.	31	26, 0	70	48, 0
September 28	2 p. m.	38		43	
September 28	4 p. m.	41		28	
September 28	6 p.m.	28		27	
September 28	8 p. m.	26		25	
September 28	10 p. m.	24		24	
September 28	12 p. m.	23	30, 0	24	28, 5
September 29	2 a. m.	23		25	
September 29	4 a. m.	24		28	
September 29	6 a. m.	24		40	
September 29	8 a. m.	27		55	
September 29	10 a. m.	29		77	
September 29	12 a. m.	32	26, 5	70	48, 5
September 29	2 p. m.	40		38	
September 29	4 p. m.	41		38	
September 29	6 p. m.	29		27	
September 29	8 p. m.	26		27	
September 29	10 p. m.	26		26	
September 29	12 p. m.	26	31	25	26, 5

(1) The figures corresponding to the curves outside of the chart are approximately calculated.

It should be noted that (1) these days were exceptionally warm, (2) the depression of the temperature of the box at about 4 o'clock corresponds to the shading of the same caused by the respective positions of the Wilson apparatus and the walls of the laboratory house, (3) that not only the Wilson's box and the sensitive thermometric cylinder, but also the air temperature registrating element and the body of thermograph were exposed to the full sunshine, on a reflective cement floor, (4) the great thermometric depression from 10 to 12 o'clock of the day September 27 corresponds to a drizzling rain.

A series of records obtained using a maximum and minimum alcohol thermometer showed that the maximum daily temperature exists from 2 to 4 o'clock in the afternoon, and oscillates between 65 and 83°C. when the day is warm and the sky is bright, and from 35 to 50°C. during rainy or dull days. Minimum temperatures correspond to the minimum of free air.

The condensation of water vapor reaches the maximum from 4 P.M. to 6 P.M. and about three fourths of the condensed water is collected during these two hours. Also a depression of the temperature during the maximum elevation is very productive in condensed water. From 4 to 10 A.M. the collection of condensed water is only occasional; no water is collected during the night.

During the first experiment, a layer about 12 cm. in thickness (5 inches) was placed in the metallic dish of the distilling box, the condensation being abundant, but the desiccation not uniform, so that frequent stirring was necessary. The best thickness of the layer of cacao beans is not more than 5 cm. (about 2 inches). Under the best conditions, one to three days are necessary for a complete drying of the seeds, and generally two days, when the cacao is unfermented, and from two to four days (most frequently three days) when unfermented. If the beans are over-dried, they appear slightly wrinkled and friable, but of good flavor and odor.

Two or three consecutive rainy days are very dangerous, if fermented or unfermented cacao beans are freshly stored in the distillation box, as the atmosphere saturated with water vapor favors the continuation of fermentation, and of course, an over-fermentation, or the rotting of cacao beans. In this case, the best prevention is the removal of the cacao from the box, and the storage in a room to protect from the rain. One day of rain followed by one day of full sunshine is not so dangerous, as the beans are par-

tially dried, and the raising of the temperature acts as a partial sterilizer.

The distilled liquor is apparently strongly acid when the beans are fermented; and weakly acid if they are unfermented and have the peculiar odor of cacao fermentation, but they were not examined chemically.

In conclusion, the drying of cacao beans by the utilization of the sunshine in such a box is promising for the cacao industry, as an easy, inexpensive and quick method, but more complete studies, made on industrial bases are necessary before forming a definite judgment.

SUMMARY

The application of Wilson's box of water distillation, utilizing the sunshine, for the desiccation of cacao beans is suggested. This method should be studied more thoroughly.

VI. THE YEASTS OF THE DOMINICAN CACAO

Fragmentary notices on the microorganisms, and particularly the yeasts (including asporigenous forms) found on cacao beans or isolated from fermenting cacao, are easily found in many papers on cacao problems, chiefly on curing of cacao. Our knowledge of yeasts of the cacao beans, during the period before the year 1927, is very incomplete. They are summarized in a comprehensive treatise by Hamel Smith et al. (**14**) on cacao fermentation. The only named and apparently specific yeast of the cacao fermentation is the "*Saccharomyces theobromae*" Preyer, but, according to Hamel Smith (**14**), De Rossi (**10**), Henneberg (**15**), and others, the presence and activity of cosmopolite yeasts (such as the elliptic yeast, the apiculate yeast, the anomalus yeast) was commonly admitted. In 1927 Lilienfeld-Toal (**19**) published a very important and exhaustive paper on yeasts (sporigenous and asporigenous), in the German language, based on material from Ecuador, Venezuela, Trinidad, Brazil, Gold Coast, St. Thomé, Ceylon, Java, etc., which was soon followed by another paper by Busse, Henneberg and Zeller (**1** bis) referring to the results of experiments on cacao fermentation.

The microorganisms isolated and studied by Lilienfeld-Toal were: (1) *Saccharomyces ellipsoideus* var. *tropicus* Lil.-Toal & Henneb., (2) *Schizosaccharomyces Bussei* Lil.-Toal & Henneb., (3) the "anomalus" yeast, (4) an undetermined "Kamhefe A", probably identic

with *Saccharomyces theobromae*, (5) an undetermined sporogenous yeast from Brazilian cacao, listed as "Weinhefe B", (6) an undetermined "Kahmhefe B"; isolated from Costa Rican and Trinidad beans, (7) an undetermined "Hefe R", asporogenous, isolated from St. Thomé samples and (8) an undetermined "Saccharomyces M", isolated from Trinidad cacao beans.

Samples of the Dominican cacao (so called 'Sánchez' type) was not included in the study of Lilienfeld-Toal. So far as the present writer is able to learn, there exists no record of experiments on Sánchez cacao, with the exception of an anascosporic yeast (*Kloecheria domingensis* Cif.), isolated from rotting cacao pods by the writer (**5**). As independently from the "vexata quaestio" of the industrial importance of the cacao fermentation, the exact nature of the yeasts causing or associated with fermentation, remains one of the major questions, and constitutes the bases for later studies. The most important purpose of this paper is to characterize the yeasts and pseudo-yeasts found on fermenting Dominican cacao beans.

The study of Lilienfeld-Toal was performed on dry cacao beans, and the yeasts isolated were those most likely adapted to survive during curing and drying. A second and minor purpose of this study was the comparison between the yeasts isolated during the fermentation and the yeasts found on dry fermented cacao beans, and their respective numerical distributions.

MATERIAL AND METHOD

During the years 1926, 1927 and 1928, isolations were made from fermenting cacao in fermetation boxes of cacao farmers located at Samaná, Sánchez, Villa Rivas, Pimentel, San Francisco de Macorís, Salcedo, Moca, Santiago, Bajabonico, La Vega, Bonao and San Cristóbal, with a total of 162 isolations. The determination of the yeasts and the distribution during the fermentation, was performed in the Agronomic National Station at Moca. The study of the yeasts remaining on dried cacao beans was made in combination with the experiments on moulds and mouldings of cacao beans.

As soon as the isolated strain was purified, the fermentation was tested, using Lindner's method for small fermentation and the strain stored. According to Redaelli and the writer's procedure (**22**), the optimum temperature for the growth was observed on the "starting medium" pepto-glucose agar, at pH = 7,00 ± 0,4), and the sporogenicity on Gorodkowa's agar. The macroscopical and microscopical

morphology was deduced from the study of cultures on (1) Raulin neutral solution, (2) carrot agar, (3) malt extract gelatine (10 per cent solution in surrogation of the beer worth), (4) malt extract water (10 per cent solution). Biochemical activities were tested, in advance of the fermentation tests, the assimilation of the carbon from the carbohydrates, alcohols, and organic acids, and assimilation of azote from organic and inorganic nitrogenous compounds. For a more detailed description of methods of study, we refer to Redaelli and Ciferri (**22**).

The classification adopted by Redaelli and the writer (**9**) as well as by the writer alone (**6**) is followed.

STRAINS N. 151, 168, 169, 174, 183, 189, 203, 207, 211, 221, 230, 249 AND 250

CULTURAL CHARACTERISTICS

Optimum temperature of growth: about 40°C.

Starting medium: colony abundant, of rapid growth, yellowish to yellow, creamy, uniform; edges thinner than the center; border irregularly sinuate.

Gorodkowa's agar: scanty growth. Easily forming spores.

Raulin's neutral solution: poor and slow growth; after two weeks, the solution is troubled; no velum; fragments of the ring; deposit not abundant, almost mucilaginous.

Carrot agar: very abundant growth: not possible to distinguish the colony from that on starting medium; a colony one week old is partly collected at the bottom of the tube.

Malt extract gelatine (geant colony): flattened, whitish-yellowish, more or less round, irregularly bordered colony, without characteristic features; center crateriform, with not well marked radial striae; no appreciable liquefaction. Must be referred to the fundamental type I of Will.

Malt extract water: quick formation of one at first pulverulent, then creamy deposit; formation of ring slow and irregular, frequently also incomplete; no superficial pellicle. A good etheric-alcoholic odor.

The color is a somewhat variable characteristic: the colonies of the strains N. 168, 183, 211 and 230 are yellow in color; strains N. 189 and 211 are almost white; other strains are yellowish to white-creamy.

Also the presence of a depressed crater is a rather variable character, well defined in the strains N. 174, 207 and 221, almost absent in the strains N. 168 and 169. Radial striae are, in a similar way, a more or less variable character.

MORPHOLOGICAL CHARACTERISTICS

Spheric, smooth, 2–4 mmm. diameter ascospores, 1 to 4 for each cell (most frequently 3), formed without previous copulation. Sporification of the cells variable from about 75 per cent (strain N. 183) to about 20 per cent (strain N. 168). Vegetative cells normally spheric, rarely sub-spheric to sub-elliptic, 3–4.5 mmm. in diameter; geant cells scarce, 5–7 mmm. in diameter. Very active, normally unipolar budding. Cells normally single, rarely from 2 to

5-chained (in the strains. N. 174 the cells are generally aggregated in little chains of 3 to 4 elements). No special morphological features. Cells of the deposit on liquid cultures are similar to the vegetative cells on solid media, but sub-elliptic in shape, 2.5–4.5 mmm. by 3–5 mmm. Cells of the ring, as rule, forming small chains (of 2 to 4 elements), showing polar or lateral budding.

BIOCHEMICAL CHARACTERISTICS

Gas production in glucose, saccharose, levulose, raffinose and maltose; fails to produce gas in galactose, mannose, rhamnose, lactose, trehalose, arabinose, xylose, sorbitol, dulcitol, melibiose, starch, soluble, destrin and inulin. It inverts saccharose and raffinose but not trehalose. Assimilates readily peptone, but no nitrate and nitrite of potassium, and ammonium sulphate. Glucose and saccharose are readily taken up; glycerin is very scantly assimilated; acetic and tartaric acids are not assimilated, or very slightly. It fails to liquefy gelatine, although it forms the nail.

SYSTEMATIC POSITION

This always present and abundant yeast belongs to the *Saccharomyces ellipsoideus* var. *tropicus* Lil.-Toal & Henneb., an intertropical yeast isolated from fermented beans of many tropical countries. This variety, in my opinion, is no other than the common ellipsoideus yeast of the wine of the temperate countries, adapted to the tropical regions. Differences between our strains and the description of Lilienfeld-Toal are slight except for the optimum temperature of growth (in our strains about 40°C., and in the Lilienfeld-Toal strains from 20 to 30°C., the higher limit being 42°C.), and the copulation as a residual sexuality ascertained by the German author. The optimum temperature of the Dominican strains are apparently more closely related to the temperature of the fermentation boxes, normally oscillating from 35 to 45°C.

STRAINS N. 172, 179, 205, 225, 236, 247, 256 AND 268

CULTURAL, MORPHOLOGIC AND BIOCHEMICAL CHARACTERISTICS

Not possible to distinguish from the preceding yeast, except by the absence of the fermenting power of galactose.

SYSTEMATIC POSITION

This yeast, almost as frequent as the *Saccharomyces ellipsoideus* var. *tropicus,* is of the same cycle, and may be distinguished from the type in a new variety: *Saccharomyces ellipsoideus* var. *domingensis* Cif., n. var. As a matter of fact, this variety is, more or less, of the same importance as the Lilienfeld-Toal's "Weinhefe B", found on Brazilian cacao beans, and a separated from the type chiefly

by the fermentation of glucose and gelactose, not of saccharose, maltose and raffinose, as well as by the tuberculated surface of the colonies on agar media. In my opinion, the brazilian strain may be classed in a variety of the same yeast; *Saccharomyces ellipsoideus* var. *brasiliensis* Cif., n. nom.

STRAINS N. 155, 159, 173, 186, 196, 223, 244 AND 258

All these strains were classified on the basis of morphological characteristics as *Endomyces anomalus* (Hans.) Zender, the cosmopolite yeast formerly known as *Saccharomyces anomalus* or *Willia anomala*.

This yeast is exceedingly frequent, and was found by Lilienfeld-Toal on samples of cacao. Judging from the cultural features on starting medium, one may distinguish many forms or varieties, chiefly by the color of the colonies, varying from the whitish to the pinkish, this characteristic probably being related to other distinctive features, but the study of our strains was limited to the micro-morphologic ones.

STRAINS N. 154, 166, 175, 190, 201, 224, 237 AND 255

Of these strains, N. 166, 190 and 237 only were studied in detail; the identification of the remaining was made from micro-morphologic characteristics. All yeasts here listed must be classified as *Schizosaccharomyces Bussei* Lil.-Toal & Henneb., a cosmopolite yeast found by Lilienfeld-Toal as one of the most diffused. The differences between the description and our strains are not appreciable: among the cultural characteristics, the optimum temperature of growth is 40°C. (37°C. according the description); the color of the colonies varies from light yellow and straw-yellow. The concentric rings of the geant colony are more or less marked, as well as the radial striae. It fails to liquefy the gelose. Assimilates peptone easily, glycocol and asparagine not at all or very scantily; nitrate and nitrate of potassium, and ammonium sulphate not at all. It readily inverts saccharose, raffinose and trehalose. It does not seem to assimilate organic acids, (malic, tartaric, acetic and citric) and glycerine (plate XXXV, fig. C).

As rightly expressed by Lilienfeld-Toal, this species is of the cycle of *Schizosaccharomyces Pombe* Lindner, from which it differs as *Schizosaccharomyces mellacei* Jorg. differs from *S. Pombe*.

For the characteristics of the asporogenous race, see *Schizotorulopsis Bussei.*

STRAINS N. 152, 165, 185, 206, 219, 220, 235 AND 240

The complete study of this yeast was made up on the strains N. 152 and 220 only, and the remaining strains classified according the microscopical appearance of the vegetative cells.

CULTURAL CHARACTERISTICS

Optimum temperature of growth: about 35°C.

Starting medium: colony abundant, thick, of very rapid growth, smooth, uniform; border unbroken, or forming very irregular and broad sinuosities, of enameled polish; ivory-white in color and creamy when young, it appears slightly yellowish and pastose when old.

Gorodkowa's agar: poorly developed. Not forming spores.

Raulin's neutral solution: it forms a heavy creamy ring, at first incomplete, later complete; there is no pellicle; the liquid medium remains clear; deposit mucilaginous, very abundant, roping, grayish in color.

Carrot agar: very similar to the starting medium, but the colonies are more developed and of more rapid growth.

Malt extract gelatine (geant colony): flat, smooth, ivory-white, of small size colony, of enameled polish, with uniform irregularly undulate borders, without crateriform central cavity, radial striae or concentric rings. Growth according the fundamental type I of Will.

Malt extract water: very similar to the growth on Raulin neutral solution.

MORPHOLOGICAL CHARACTERISTICS

Asporigenous. On solid media, young cells are typically and more or less regularly apiculate; old cells are irregular in shape, from apiculate to ellipsoid, obovate and spheroid, single. Budding very active, normally bipolar. Geant cells scarce or absent, slightly larger than the normal ones. Vegetative cells from 3 to 6 mmm. in diameter or in length, most frequently from 3.5 to 5 mmm. Cells of the ring on liquid media very similar to the preceding, single to aggregated in short chains composed of 2 to 4 cells. Cells of the deposit more frequently round than apiculated, always single, but mechanically aggregated or tangled, mucous; the protoplasm is filled with oil drops and crystalloids; there may be degenerative forms and absence of budding.

BIOCHEMICAL CHARACTERISTICS

It ferments glucose readily but does not ferment levulose, sorbitol, dulcitol, abinose, xylose, rhamnose, mannose, galactose, maltose, lactose, melibiose, saccharose, trehalose, raffinose, starch, soluble dextrin, glycogen and inulin.

It inverts saccharose, but not trehalose; the inversion of raffinose, if any, takes place with difficulty. Strain N. 185 inverts raffinose; other strains do not invert the same hydrocarbonate. Glucose, levulose and saccharose are easily assimilated; galactose and mannose not readily and lactose not to any extent. Assimilates acetic acid well; tartaric, malic and citric acid not readily; methylic and ethylic alcohol not to any extent. Assimilates glycerin very

slowly. Pepton is preferred, but asparagine is assimilated quite well; nitrate of potassium and sulphate of ammonium are assimilated slowly but not nitrite of potassium nor glycocol. Starch is not hydrolized and gelatinase is not produced. This yeast grows apparently without difficulty in media containing 1 per cent of acetic acid.

SYSTEMATIC POSITION

Many tropical species of the genus *Kloeckeria* Janke (showing apiculate, asporogenous cells) were isolated chiefly from the soils and described by Klöcker, but most of them are not completely characterized and easily distinguished, and a comparison with our species cannot be made satisfactorily. The present writer (5) described a species of *Kloeckeria* (*K. domingensis* Cif.), isolated from washing water of rotting cacao pods, very rarely found on fermenting cacao beans, and only at the beginning of the fermentation. *K. domingensis* is very distinct from the strains in study, in having larger cells (6–12 by 4–8 mmm.), very regular in shape when young; ferments levulose and glucose only slightly; assimilates glucose, saccharose, levulose and maltose, but not acetic acid; an hydrogen-ion concentration of pH = 5,0–4,6 interrupts the growth. In expectation of the revision of the species of *Kloeckeria* indicated to date, we describe the form in study as a new species: *Kloeckeria cacaoicola* Cif., n. sp.

Strains N. 182, 202 and 254

The strains in study must be referred to the *Kloeckeria domingensis* Cif., previously described (5).

Strains N. 158, 163, 167, 184, 197, 199, 210 and 228

Only four strains (N. 158, 163, 184 and 210) were completely studied, the remaining being determined on the basis of cultural characteristics and morphological aspect of the cells on starting medium, as well as on the basis of the fermentation.

CULTURAL CHARACTERISTICS

Optimum temperature for growth: about 35°C.

Starting medium: thin, flat, white to ivory-white, then white-grayish or white-yellowish, mat, more or less regularly rounded colonies, with smooth surface, and smooth plain or irregularly undulate borders.

Gorodkowa's agar: thin, depressed, almost pellicular, poor colonies; cells without ascospores.

Raulin's neutral solution: quick growth, forming a superficial ring at first incomplete, later complete, but irregularly thickened, with a few very small floating islets, but without a well developed velum; easy formation of an

abundant, more or less pulverulent deposit at the bottom of the test tube; the liquid remains clear.

Carrot agar: very abundant development, similar to the growth on the starting medium.

Malt extract agar (geant colony): flat, white to whitish, finally mat, rounded colony, showing a small slightly depressed center (crateriform), sorrounded by a peripheric ring; colony thinner at the periphery, with a few not well defined radial striae, but without concentric rings; borders undulate or not, finely ragged in the sub-superficial portion of the colony, but smooth at the surface.

Malt extract water: the same growth as in Raulin's neutral solution, but more abundant at the bottom of the tube; the liquid of culture is slightly decolorized; without any peculiar odor (Plate XXXV, fig. B).

MORPHOLOGICAL CHARACTERISTICS

Young cells cultivated on solid media are generally, ovate or elliptic to elliptic-elongate, with unipolar, rarely bipolar budding, 3 to 5 mmm. in diameter or in length; geant cells not very frequent, more or less rounded, 4 to 6.5 mmm. in diameter not clearly distinct form the normal cells; cells single, rarely aggregated in short chains composed of 2 to 4 cells. Cells of the ring developed on liquid cultures similar to the preceding, but frequently aggregated in chains, straight or branched, composed of 2 to 7 elements; also lengthened, ellipsoid to sub-cylindric cells, 6–9, (generally 6–7 mmm.) by 3–5 mmm., single or chained together with the normal cells. Cells of the small floating fragments of the pellicle completely similar to the preceding, but composed of numerous elongate cells, and a few short normal cells. Deposit composed of more or less rounded to ovate or elliptic cells, with scarce single, buds, showing involutive or degenerative forms, and a more or less disorganized protoplasm. All young cells possess one vacuole, not rarely two or more small vacuoles, and at first one or two fat globules, then many small globules.

BIOCHEMICAL CHARACTERISTICS

Ferments glucose easily and abundantly, not arabinose, xylose, rhamnose, mannose, galactose, levulose, sorbitol, dulcitol, maltose, lactose, melibiose, saccharose, trehalose, raffinose, starch, soluble dextrin, and inulin. Fermenting power is very strong in a few strains (as N. 163, 184, 197 and 199), and very reduced in a few other (as N. 184 and 228). Assimilates well glucose, levulose, galactose, maltose and saccharose; also abundantly acetic and citric acid, less tartaric and slightly malic acid; assimilates ethylic alcohol, but not methylic alcohol. It growths very well on peptone solution, and well also in asparagin, nitrate of potassium and sulphate of ammonium solution; the development is poor on nitrite of potassium and on glycocol solutions. Inverts readily saccharose and raffinose, very sparingly trehalose.

SYSTEMATIC POSITION

This form, one of the most frequent asporogenous yeasts, found on fermenting cacao, in spite of the small difference of the cultural and morphologic characteristics, is identical to the "Kahmhefe A"

of Lilienfeld-Toal, found in cacao samples of all countries. In the opinion of the German author, the "Kahmhefe A" is identical, or, at least, very similar to the "*Saccharomyces theobromae*" Preyer, and I agree with him, taking in consideration the necessity of a right interpretation of the so called "spores" of the original description, and the cultural characteristics as referred to the peculiar cultural substratum. For the presence of fat globules in young cells, and the development of the yeast on liquid media according the fundamental form I of Will, this form should be assigned to the genus *Eutorulopsis* Cif. (*Eutorula* Will and not Saccardo). Of the asporigenous yeasts described as species of the genus *Eutorulopsis*, and not producing pigment in culture, two are known: *E. vulgaris* (Will) Cif. & Red and *E. ellipsoidea* (Will) Cif. & Red. The organism studied differs from both strains, in the cultural, morphologic and biochemical standpoint, so that the Preyer's species can be maintained, but transferred to the genus *Eutorulopsis*: *Eutorulopsis theobromae* (Preyer) Cif., n. comb.

STRAINS N. 157, 171, 187, 198, 222 AND 245

Another very common asporogenous yeast, of the same type as the preceding. Only the strains N. 157 and 198 were studied in detail.

CULTURAL CHARACTERISTICS

Optimum temperature for growth, about 40°C.

Starting medium: white-grayish to light-grayish, small, flat, almost pellicular, irregular colonies, very thin, of an uniform thickness or slightly thicker at the borders; borders more or less irregularly sinuate-undulate. Old colonies are gray in color.

Gorodkowa's agar: poor growth, very similar to the preceding, but showing less developed colonies. Not forming spores.

Raulin's neutral solution: quick superficial development, forming a continuous but thin ring and at first cob-webby, then thicker velum; the superficial pellicle is fragmented, but almost entire in old colonies, grayish, finely folded; deposit slimy and abundant, grayish in color; no peculiar odors.

Carrot agar: very similar to the cultures on starting medium.

Malt extract gelatine (geant colony): colony of slow growth, grayish in color; flat, smooth, superficial, forming a great central crateriform depression, without striae, and not well marked concentric rings; borders continous or irregularly and broadly sinuate, in the subsuperficial portion finely striated.

Malt extract water: growth similar to that on Raulin's neutral solution.

One of the most distinctive features is the slow growth of the colonies at the optimum temperatures, in any liquid or solid media (plate XXXV, fig. D and F).

MORPHOLOGICAL CHARACTERISTICS

Cells developed on solid media ovate to elliptic, rarely sub-cylindric or sub-elongate, 2.5–5 by 4–6 mmm., normally 2.5–4 by 3–5 mmm., the longest being 8 mmm. Geant cells not frequent, spheric, 5–7 mmm. in diameter. Cells single or chained (from 2 to 20, rarely more) forming straight or sparingly branched chains; also crown-like aggregation of 10–30 cells are present. Chains and crown are exceptional on solid media cultures, but normal in the superficial velum, and quite frequent in the ring. Budding, unipolar on solid media cultures, and bipolar on the cells of the velum and ring, is very active only on solid media. Cells of the deposit are single or mechanically aggregated by a connective mucosity, or more or less free; they are very scarcely budding, frequently guttulated or vacuolated, showing involutive strange forms. Geant cells are very frequent.

BIOCHEMICAL CHARACTERISTICS

Does not produce gas in arabinose, xylose, rhamnose, glucose, mannose, galactose, fructose, sorbitol, dulcitol, maltose, lactose, melibiose, saccharose, trehalose, raffinose, starch, soluble dextrin and inulin. It inverts saccharose and raffinose, not at all trehalose. Liquid media containing glucose, maltose, levulose and saccharose are preferred. It develops quite well on acetic acid solution, and in presence of ethylic alcohol, less on tartaric, malic and citric acids, glycerin and methylic alcohol. Peptone solution is preferred, but nitrate of potassium and ammonium sulphate solution are admitted. The liquefaction of the gelatine is very small.

SYSTEMATIC POSITION

This yeast, almost as frequent as the preceding yeast, is easily distinguished from the *Saccharomyces theobromae* by the velocity of the growth, which is rapid in the Preyer's fungus, and slow in this species. In our opinion, this yeast is similar or identical to the "Kahmhefe B" of Lilienfeld-Toal, isolated from Costa Rican and Trinidad cacao beans, but this yeast was not as completely studied by the German author as the other yeasts, so that a complete comparison cannot be made.

This asporogenous yeast must be included in the genus *Eutorula* (*Torula* of the zymologists, p. p.), in spite of presence of chains both straight and branched, crown-like figures, etc. These aggregations, if found both on liquid and solid media, are characteristics of the genus *Blastodendrion* (Ota), which geant colonies are intermediary between the typical geant colonies of the Mycotoruleae and the same of the Torulopsideae. In the fungus at hand, cell aggregations are found almost only on liquid media cultures, and the geant colony is, of course, of the type I of Will (Torulopsideae). At this time the systematic position of the colourless species of the genus *Torulopsis* is so chaotic that an efficient compari-

son is impossible, and therefore we should create a new species "ad interim", which we will name *Torulopsis Lilienfeld-Toalii* Cif., n. sp., dedicated to the distinguished German zymologist Dr. O. A. von Lilienfeld-Toal.

This species differs from the formerly studied yeast by the velocity of the growth, the presence of a complete superficial pellicle, the aggregations of the cellular elements on liquid media cultures, as well as by many biochemical characteristics, chiefly by the absence of the fermentative power.

Strains N. 156 and 234

This yeast is probably of accidental presence in the fermenting cacao.

CULTURAL CHARACTERISTICS

Optimum temperature for growth: about 30°C.

Starting medium: growth rapid; colony at first white, later white-yellowish, dense, creamy, opaque, thick; the center of the colony is smooth and uniform, the border is thinner, grossly and irregularly lobate.

Gorodkowa's agar: very poor growth; single colonies small, round, whitish, flat, partially confluent in a larger colony. No ascospores formation.

Raulin's neutral solution: poorly developed; only fragments of the ring are present, and the deposit, pulverulent and whitish, is not abundant; no pellicle; does not produce peculiar odors.

Carrot agar: characters similar to those observed on the starting medium, but more pronounced; most of the colony run to the bottom of the test tube.

Malt extract gelatin (geant colony): white or whitish, flat, circular, small colony, slowly forming an enlarged central depression, but not of the crateriform type; radial striae or concentric rings are not formed; irregularly sinuate, linear, thin, smooth borders. Geant colony of the Will's fundamental type I.

Malt extract water: as in Raulin neutral solution, but more abundant.

MORPHOLOGICAL CHARACTERISTICS

Does not form ascospores. Cells more or less spheric to spheroid, rarely elliptic to avoid, 3.5–5.5 by 4–6.5 mmm., with unipolar, rarely bipolar budding. Cell single, rarely aggregated in short chains composed of 2 to 4 elements, without complicated aggregations. Geant cells scarce on solid media, more abundant on liquid ones, spheric, 6–8 mmm. in diameter, scarcely distinguished from the normal cells. Cells of the ring spheric to elliptic, 3–5 mmm. in diameter, or 3–4 by 4–6 mmm., normally aggregated in short straight chains composed of 2 to 6 elements; the budding is scarcely active. Cells of the deposit in liquid cultures similar to those on solid media, but with a more or less disorganised protoplasm, frequent involutive forms, and without budding.

BIOCHEMICAL CHARACTERISTICS

Does not produce gas in arabinose, xylose, rhamnose, glucose, mannose, galactose, sorbitol, dulcitol, maltose, lactose, saccharose, trehalose, raffinose, starch, soluble dextrin and inulin. Inverts saccharose, raffinose, and trehalose. It is not difficult on the selection of sugars as source of carbon: glucose, levulose, maltose and galactose are of the same importance. Does not develop in methylic and ethylic alcohol solutions, as well as on acetic, citric, malic and tartaric acids, and on glycerine. The growth is very abundant on peptone, and scarce or not at all on glycocol, asparagine, potassium nitrate and nitrite and ammonium sulphate. On gelatine cultures, a slow liquefaction takes place.

SYSTEMATIC POSITION

This species is clearly distinct from the preceding, as well as from the *Eutorulopsis* variety isolated from the Dominican cacao. The problem of the comparison of the species in study among the to date more or less completely described species of the genus Torulopsis, remains the same; thus we should create a new species "ad interim", dedicated to Mr. Hamel Smith, pioneer of the study on cacao fermentation, which we will name, *Torulopsis Hamel-Smithii* Cif., n.sp.

STRAIN N. 161

This strain, isolated together with strains of the *Schizosaccharomyces Bussei*, is indistinguishable by cultural, morphological and biochemical standpoint from this yeast, with the exception of the following characteristics: (1) fails to produce ascospores on Gorodkowa's medium, as well as on chalk cones and on sterilized carrot; (2) the enormous production of arthrospores (or *Oidium*-like cells), chiefly in liquid media; (3) in spite of the absence of the ascospore production, a more or less complete conjugation of the cells may rarely be observed; after the copulation, the cell remains inactive; (4) the fermentative power very reduced, but the same carbohydrates are fermented.

In spite of the fact that the transformation of the *Schizosaccharomyces Bussei* into the asporogenous form or "viceversa" was not experimentally demonstrated, there are no doubts on the relation between ascogenous and anascosporic strains. On the other hand, Lilienfeld-Toal observed the presence of asporogenous strains.

The imperfect form of the genus *Schizosaccharomyces* must be classified under the genus *Schizotorulopsis* Cif., of which only one species is surely known (*S. Alfonsecai* Cif.), not to mention the *S. asporus* Eykman and named: *Schizotorulopsis Bussei* Cif., n. nom.

STRAIN N. 215–215 BIS.

This strain was isolated for the first time in January 1927 from fermenting cacao from a cacao estate located at La Vega. It was generically determined, and the failure to produce fermentation ascertained. Before the transplant of the month of July, the strain died. A new casual reisolation was made during the month of October of the same year from a fermenting cacao of a cacao farm of Moca, and the study was completed without delay. Five months after the reisolation, I also lost the second strain.

CULTURAL CHARACTERISTICS

Optimum temperature for growth: about 40–42° C.

Starting medium: white or whitish, creamy, slimy, not abundant colonies, of slow growth also at the optimum temperature, and very slow at lower temperatures; the colonies are smooth, glassy, without distinctive particularities.

Gorodkowa's agar: very small, lenticular, alabastrine, scattered colonies. Not forming spores.

Raulin's neutral solution: very reduced development, both superficial and at bottom; only small and scattered fragments of rings are formed; no superficial pellicle; very scarce, slimy, white-yellowish deposit.

Carrot agar: of the cultural subtrata tested, this agar appears as the best; colony very similar to those on starting medium, but more abundant.

Malt extract gelatine (geant colony): very small, round, flat, white, smooth colony, without crater, rings or striae; borders plain, smooth, uniform. The type of the colony is the I type of Will.

Malt extract water: development similar to that on Raulin's neutral solution, but slightly abundant; the ring is more developed.

MORPHOLOGICAL CHARACTERISTICS

Cells developed in cultures on solid media clearly biform; most frequently sphaeric to subovate, about 4 to 6 mmm. in diameter, mixed with elliptic-lengthened or cylindroid cells, of 7–12 by 5–8 mmm. The multiplication effected is by a process beginning by budding and ending by fission, as described in the genus *Schizoblastosporion*. Cells of the ring on liquid media cultures similar to the preceding but most abundant cells are the elongate instead of the rounded. Cells of the deposit generally spheric, frequently showing degenerative forms, with a more or less spoiled protoplasm; geant cells present but scarce, not easily distinct from normal spheric cells but for a thicker membrane and a slightly greater (diameter 5–7.5 mmm.).

BIOCHEMICAL CHARACTERISTICS

They do not ferment arabinose, xylose, rhamnose, glucose, mannose, galactose, fructose, sorbitol, dulcitol, maltose, lactose, melibiose, saccharose, trehalose, raffinose, starch, soluble dextrin and inulin. Does not invert saccharose, trehalose and raffinose. Assimilates abundantly only glucose and levulose, not maltose, saccharose, mannose, galactose and lactose, nor organic acids, or alcohols. Growth good only on peptone solution. Fails to liquefy gelatine; does not

produce sulphuretted hydrogen from powdery sulphur; fails to produce indol or trytophane, and does not give the biuret reaction; does not hydrolize starch; methylene blue solution is decolorized very slowly.

SYSTEMATIC POSITION

This strain falls under the genus *Schizoblastosporion*, a genus of asporigenous yeasts characterized by the reproduction by budding-fission. The only species to date described is the type of the genus: *S. Starkeyi-Henricii* Cif. (**5**), isolated from North American soil. Under the denomination "Hefe R", Lilienfeld-Toal isolated from cacao of St. Thomé another strain of Torulopsidacea, undoubtedly pertaining to the same genus *Schizoblastosporion*. Differential characteristics between *S. Starkeyi-Henricii*, "Hefe R", and our strain are summarized in the following table.

Schizoblastosporion Starkeyi-Henricii	"*Hefe R*" *of Lilienfeld-Toal.*	*Strains N. 215-215 bis of Ciferri.*
Apparently of strong vitality.	In culture 50% of the cells dead.	of feeble-vitality.
White colony.	Yellowish colony.	White or whitish colony.
No pellicle.	Mucous pellicle.	No pellicle.
Rapid growth.	Slow growth.	Slow growth.
?	Liquefy gelatine.	Not liquefy gelatine.
?	Optimum temp. 20°C.	Optimum temp. 40-42°C.
Cells not very mucous.	Cells very mucous.	Cells not very mucous.
Spheric cells 2-7 mmm. of diameter.	Spheric cells 6, 5-7 mmm. of diameter.	Spheric cells 4-6 mmm. of diameter.
Elongate cells 10-22 by 5.5-7 mmm.	Elongate cells 10 by 20 mmm.	Elongate cells 7-12 by 5-8 mmm.
Without geant cells.	With geant cells.	With geant cells.
Glucose is preferred.	Glucose is preferred.	Glucose and levulose are preferred.

These differences are, in our opinion, distinguishing the "Hefe R" from the strains N. 215–215 bis, and both from *S. Starkeyi-Henricii*, basing our opinion on the cultural, morphological and biochemical differences above summarized. According to these conclusions, we propose the binomial *Schizoblastosporion santhomensis* Cif., n. nom. for the Lilienfeld-Toal's "Hefe H", and *Schizoblastosporion domingensis* Cif., n. sp. for the strains N. 215–215 bis.

In closing, from the study direct or indirect of two other species of the same genus, we are able to perfect the generic description of *Schizoblastosporion* Cif.: asporogenous yeast, in which multiplication begins by budding and ends by fission; frequently of feeble vitality; without fermentative power; assimilation of carbon and azote generally specialized from one or a few determined compounds; cells always bimorphe, the smaller spheric and the longer elliptic to cylindric.

STRAIN N. 216

Isolated only once from dry fermented cacao beans, but here

very abundant. This strain must be considered as the *Torula aurantiaca* Saito (25), isolated from the air in Manchury. This species being well known from Saito's description, we are adding only the characteristics not previously observed, or different from those of the Japanese author.

CULTURAL CHARACTERISTICS

Agar cultures are generally abundant, easily developed, smooth, with plain or irregular, simple borders. Gelatine cultures of the same type of all simple Torulopsidaceae (I fundamental type of Will), with a small central depression, and simple, and smooth borders. Cultures in liquid media forming a small, rather incomplete ring, and a more or less abundant deposit, but not pellicle. Optimum of temperature for growth about 30°C. Cells normally not aggregated in chains, and not forming arbuscula, crowns, and so on. Does not ferment arabinose, xylose, rhamnose, glucose, mannose, galactose, fructose, sorbitol, dulcitol, maltose, lactose, melibiose, saccharose trehalose, raffinose, starch, soluble dextrin and inulin. Does not invert raffinose. Develops abundantly on glucose, levulose, maltose and galactose, as well as peptone, less on asparagine, nitrate of potassium and ammonium sulphate.

SYSTEMATIC POSITION

This species is reported for the first time found outside of the type locality, and probably, accidentally present on fermenting cacao, should be transferred to the genus Torulopsis as *Torulopsis aurantiaca* (Saito) Cif. & Red.

STRAIN N. 204

This strain was isolated only one time, and as the preceding strain, must be considered as an accidental contamination of the fermenting cacao beans. It may be considered as identical with the *Torulopsis mucilaginosa* (Jörgens.) Cif. & Red., a pinkish Torulopsidea, described by Jörgensen (16) and revised and reclassified by the present writer and Redaelli (8).

STRAIN N. 153

As the preceding two strains, but exceedingly frequent on the sample examined. In our opinion, this strain is a variety of the *Torula rumosa* Saito (25), a Mycotorulea, that, according the description of the Japanese author, as well as the observation on the strain at hand, must be referred to the genus *Mycotorula* Will as *Mycotorula ramosa* (Saito) Cif., n. comb. Only differential characteristics from Saito's description are indicated.

CULTURAL CHARACTERISTICS

On favorable solid media the colonies are abundant, at first smooth, then with plume-like borders, and with an abundant sub-superficial development of root-like mycelium. The borders are finely engraved to dentate, and under the microscope, a dense, net-like work is visible. On gelatine, the geant colony is clearly sulcate by radial, simple or branched, striae, starting from a depressed to crateriform center to the periphery. No or only sketchy concentric rings are visible. Borders dentate and plume-like, with a dense sub-superficial mycelium vegetation. On liquid media, the development is abundant, forming at first a complete and generally dense ring, then a serie of floating islets, finally aggregated into an orange-reddish, finely folded, mat superficial pellicle. The deposit is ropy, brownish in color. The color of the colonies on solid media oscillate form gold-yellow to orange-reddish.

MORPHOLOGICAL CHARACTERISTICS

The morphology of the cell is very similar to that described by Saito, but the cells of the velum reach 30 mmm. in length and 6.5 mmm. of thickness. Geant spheric cells are frequent in the deposit of liquid cultures, being from 6 to 9 mmm. in diameter.

BIOCHEMICAL CHARACTERISTICS

Does not ferment arabinose, xylose, rhamnose, glucose, mannose, galactose, fructose, sorbitol, dulcitol, maltose, lactose, saccharose, trehalose, raffinose, starch, soluble dextrin and inulin. Inverts trehalose, saccharose and raffinose. Liquefies gelatine slowly. Growth good on glucose, saccharose, multose, but not on levulose and galactose. Only the peptone is favorable. The optimum of the temperature for growth is lower than 30°C.

SYSTEMATIC POSITION

This strain differs from the *Mycotorula ramosa* in many particulars of the colonies both on solid and liquid media, as well as in the morphology of the cells and in the biochemical characteristics. For this variety we propose the name: *Mycotorula ramosa* (Saito) Cif. var. *dominicana* Cif., n.var.

Strains N. 160, 162, 164, 170, 176, 177, 188, 192, 214 and 227

All these strains are referable to the genus *Geotrichum* (*Mycoderma* of Auct. sensu stricto, or *Oidium* of the zymologists, pro parte). With the exception of the strains N. 164, 177 and 192, all others are not easily distinguished from the morphological and biochemical points of view, while cultural characteristics are but little differentiated. For brevity, the most outstanding characteristics only are summarized.

Strain N. 160

CULTURAL CHARACTERISTICS

On solid favorable media, it forms a poorly developed, folded, white, pellicular colony in which borders are more or less plume-like. In favorable liquid media, the ring is fused to a well developed, white-folded, thin, dusty, at last floating pellicle; the deposit is abundant and slimy. The geant colony on malt extract agar is thin, pellicular, finely but indistinctly folded, chiefly at the borders, but without concentric rings. This yeast does not liquefy the gelatine.

Strain N. 162

CULTURAL CHARACTERISTICS

On solid favorable media, it forms an abundant, white-grayish to white-yellowish mat, thick, at first smooth, then more or less woolly, irregularly but very densely cerebroid or mesentheroid-folded colonies. The borders are thick, almost smooth. In favorable liquid media, the pellicle is abundant, yellowish, cerebriform-sulcate, dense; the ring is fused with the pellicle. The geant colony on malt extract agar is thick, irregularly cerebriform-convolute, with a broad central depression. The gelatine is not liquefied, or very slow.

Strain N. 164

All cultural characteristics are similar to those of the strain N. 160, but the colonies on solid media are more developed.

Strain N. 170

Very similar to the strain N. 160; the deposit is mucous more than slimy, and the geant colony shows more well marked radial striae and almost indistinct concentric rings.

Strain N. 176

Similar to the strain N. 162, but thinner and yellowish in color.

Strain N. 177

CULTURAL CHARACTERISTICS

Very abundant, whitish, dry, plain, abundant and of rapid growth colonies, covered by a dense cottony layer, when developed on solid favorable media. In liquid media, the velum is cottony or densely wool-like, but irregularly developed, almost white in color, at last floating. The geant colony on malt extract agar is very well developed, almost hirsute, under the superficial cotton-like layer, crenulate, dry; the borders are uniform and plain. The center is somewhat prominent, but irregularly, and one or few not well marked concentric rings are visible. The gelatine is not liquefied.

Strain N. 188

Similar to the preceding, but with well marked radial striae, and more or less indistinct concentric rings. The colonies on solid media are more developed, and a slow but diffused liquefaction of the gelatine takes place. The colonies are always smooth, never crenulate.

Strain N. 192

Not distinct from the strain N. 188.

Strain N. 227

Very similar to the strain N. 162.

Strains N. 160, 162, 164, 170, 176 177, 188, 192 214 and 227.

MORPHOLOGICAL CHARACTERISTICS

Very similar in all studied strains. Arthrospore generally from 3.5 to 6 mmm. by 5 to 12 mmm.; mycelic hyphae more or less slender, branched, septate, of the same thickness. Strains N. 160, 164 and 170 have only creeping hyphae; strains N. 162, 176 and 227 abundant creeping hyphae, but also a few, short and poorly developed, sub-erect, hyaline, sparingly branched hyphae; strains N. 177, 188 and 192 possess creeping hyphae as well as erect, densely branched, cottony, septate, apparently true myceliar hyphae. All creeping hyphae easily produces chained arthospores; sub-erected hyphae may produce arthrospores only in contact with the solid substrata; erected, true myceliar hyphae; apparently never produces arthrospores.

BIOCHEMICAL CHARACTERISTICS

The most outstanding difference is the power of liquefying the gelatine. Studied strains do not ferment any tested carbohydrate; growth good on glucose, saccharose, maltose, and levulose; less on galactose; ethylic alcohol, as well as acetic and citric acid (less on tartaric and malic) are accepted; not so well glycerine; not to any extent on methylic alcohol. Peptone, asparagine, nitrate of potassium and sulphate of ammonium are easily accepted; not so well glycocol; not or very little on nitrite of potassium.

SYSTEMATIC POSITION

Up to the present time the species of the genus *Geotrichum* are generally grouped in a few, more or less distinct species, or included under comprehensive determination that is so bewildering that a comparison with our strains cannot be made. For this reason we prefer the temporary grouping into species and variety on the base of the tested differences, according to the following key:

A. Cerebriform-sulcate colonies, more or less woolly, whitish to yellowish, slowly or not liquefying the gelatine (Strains N. 162–type, N. 176 and 227.)—*Geotrichum cerebrinum* Cif. n. sp.

B. Pellicular, smooth, poorly developed colonies, whitish to yellowish, not liquefying the gelatine (Strain N. 160–type, N. 164 and N. 170).—*Geotrichum flexuosum* Cif., n. sp.

C. Colonies showing striae and concentric rings, covered by a cottony layer, white to grayish in color.

  a. Crenulate colony; not liquefying gelatine (strain N. 177).—*Geotrichum byssinum* Cif., n. sp.

  b. Smooth colonies, liquefying the gelatine (strain N. 188–type and N. 192).—*Geotrichum byssinum* Cif. var. *rigidum* Cif. n. var.

YEASTS FOUND IN SANTO DOMINGO AS COMPARED TO THE YEASTS FOUND IN OTHER COUNTRIES

The yeasts common to Santo Domingo and other tropical countries, as found on fermenting, or fermented cacao beans, are the following:

1. *Saccharomyces ellipsoideus* var. *tropicus* Lil.–Toal & Henneb.—Intertropical.
2. *Endomyces anomalus* (Hans.) Zender.—Intertropical.
3. *Schizosaccharomyces Bussei* Lil.–Toal & Henneb.—Intertropical.
4. *Eutorulopsis theobromae* (Preyer) Cif. ("Kahmhefe A" Lil.–Toal).—Intertropical.
5. *Schizotorulopsis Bussei* Cif.—Intertropical.

The following yeasts are common to Santo Domingo and other countries, but not tropical countries, nor on fermenting or fermented cacao beans:

6. *Torulopsis aurantiaca* (Saito) Cif. & Red.—Manchury.
7. *Torulopsis mucilaginosa* (Jörg.) Cif. & Red.—Europe.

The following yeasts are found only in Santo Domingo, on the same substratum:

8. *Saccharomyces ellipsoideus* var. *domingensis* Cif.
9. *Kloeckeria cacaoicola* Cif.
10. *Kloeckeria domingensis* Cif.
11. *Torulopsis Lilienfeld-Toalii* Cif.
12. *Torulopsis Hamel-Smithii* Cif.
13. *Schizoblastosporion domingensis* Cif.
14. *Mycotorula ramosa* (Saito) Cif. var. *dominicana* Cif.
15. *Geotrichum cerebrinum* Cif.
16. *Geotrichum flexuosum* Cif.
17. *Geotrichum byssinum* Cif.
18. *Geotrichum byssinum* Cif. var. *rigidum* Cif.

The following yeasts, not found in Santo Domingo, are described on fermented cacao of other tropical countries:

19. *Saccharomyces ellipsoideus* Hans. var. *brasiliensis* Cif. (="Weinhefe B" Lil.–Toal).—Brazil
20. *Schizoblastosporion santhomensis* Cif. (="Hefe R" Lil.–Toal).—San Thomé.
21. *Torulopsis neotropica* (*) Cif., n.nom. (="Kahmhefe B" Lil.–Toal).—Costa Rica and Trinidad.
22. *Saccharomyces theobromae-fermentans* Cif., n.nom. (**) (="Saccharomyces M" Lil.–Toal).—Trinidad.

THE FERMENTATION OF THE CACAO AND THE YEAST DISTRIBUTION

The distribution of the yeasts in relation to the course of fermentation may be deduced from the isolations made during the experiments. Judging from the strains isolated, we may divide the yeasts in: (1) yeasts normally present during the fermentation of cacao, and (2) yeasts of accidental or occasional presence. The yeasts of the first category, and, of course, that may play a role in the fermentation, are: (1) *Saccharomyces ellipsoideus* var. *tropicus,* (2) *S. ellipsoideus* var. *domingensis,* (3) *Endomyces anomalus,* (4) *Schizosaccharomyces Bussei,* (5) *Kloeckeria cacaoidola,* (6) *Eutorulopsis theobromae.* Less frequent, but not of exceptional presence, are: (1) *Torulopsis Lilienfeld–Toalii* and (2) *Kloeckeria domingensis.* Accidentally found on fermenting cacao beans are: (1) *Torulopsis Hamel-Smithii,* (2) *Schizoblastosporion domingensis,* (3) *Torulopsis auranticaca,* (4) *Torulopsis mucilaginosa,* (5) *Mycotorula ramosa* var. *dominicana,* (6) *Geotrichum cerebrinum,* (7) *G. flexuosum,* (8) *G. byssinum,* (9) *G. byssinum* var. *rigidum.*

In relation to the frequency of each species or variety of yeast, and the period of fermentation, including the period of post-fermentation, we may consider four phases, namely: (1) beginning of fermentation, (2) fulness of fermentation, (3) end of fermentation, (4) persistance on dry fermented cacao beans, conserved at the normal conditions, six months after the fermentation. In the scheme of the yeasts distribution, the absence of the species is expressed

(*) From the description of Lilienfeld-Toal, it is almost impossible to arrange this yeast in one of the genera of the asporigenous. As species of *Torulopsis* it is not typic of the genus.

(**) According to the German author above quoted, this yeast is similar both to *Willia anomala* and *Saccharomyces lactis* Dombrowski, but it is apparently more like the *Saccharomyces fragilis* Jörg. It differs from the three above quoted species by many cultural, biochemical and morphological characters, and may be a distinct and new species.

by O; + indicated very rare; + + quite rare; + + + common; + + + + very common.

Yeast	Beginning of fermentation	Fulness of frementation	End of fermentation	Dry beans
Saccharomyces ellipsoideus var. tropicus	+ +	+ + + +	+ + +	+ + +
S. ellipsoideus var. domingensis	+ +	+ + +	+ + +	+ + +
Endomyces anomalus	+ + +	+ +	+ +	+ +
Schizosaccharomyces Bussei	+	+ + +	+ + +	+ +
Kloeckeria cacaoicola	+ + +	+ +	+	0
Eutorulopsis theobromae	+ + +	+ + + +	+ + + +	+ + +
Torulopsis Lilienfeld-Toalii	+ +	+ + +	+ + + +	+
Kloeckeria domingensis	+ + +	+	0	0
Torulopsis Hamel-Smithii	+ +	0	0	0
Schizoblastosporion domingensis	+	0	0	0
Torulopsis aurantiaca	0	0	+	0
Torulopsis mucilaginosa	0	0	0	+
Mycotorula ramosa var. dominicana	0	0	+	0
Geotrichum cerebrinum	0	0	+	+
G. flexuosum	0	0	+	+
G. byssinum	0	0	0	+
G. byssinum var. rigidum	0	0	+	0

KEY TO THE GENERA, SPECIES AND VARIETIES OF CACAO YEASTS

A. Sporogenous yeasts (*Saccharomycales*).

I. **Without true mycelium (*Saccharomycetaceae*).**

1. **Multiplication by budding (*Saccharomyces* Meyen).**

a. The ellipsoid type (*Saccharomyces ellipsoideus* Hansen).

b. **Fermenting glucose, raffinose, levulose, saccharose, maltose** and galactose. — *S. ellipsoideus* Hans. var. *tropicus* Lil.-Toal.

***bb.* Fermenting glucose, raffinose, maltose, saccharose, levulose but no galactose.—*S. ellipsoideus* Hans. var. *domingensis* Cif.**

***bbb.* Fermenting glucose and galactose only.—*S. ellipsoideus* Hans. var. *brasiliensis* Cif.**

***c.* Not so.—*S. theobromae-fermentans* Cif.**

2. Multiplication by fission (*Schizosaccharomyces* Linder).

Only species.—*S. Bussei* Lil.-Toal & Henn.

II. With a true mycelium (*Endomycetaceae;* genus *Endomyces* Rees). **Only species.—*E. anomalus* (Hans) Zender.**

B. Asporogenous yeasts (*Atelosaccharomycetaceae-Torulopsilaceae*).

I. Without a true mycelium (*Torulopsideae*).

1. Multiplication by budding.

***a.* Cells spheric, ovate to ellipsoid.**

***b.* Young cellules with one or more fatty corpuscles; growing according to Will's fundamental form I (*Eutorulopsis* Cif.)**

Only species.—*E. theobromae* (Preyer) Cif.

***bb.* Young cellules without fatty corpuscules, growing according to Will's fundamental form III (*Torulopsis* Berl. emend).**

c. Colonies pink or red to orange in color.

d. Colonies orange in color, developing abundantly in glucose, levulose, maltose and galactose solution.—*T. aurantiaca* (Saito) Cif. & Red.

dd. Colonies pinkish, developing abundantly in saccharose solution only.—*T. mucilaginosa* (Joerg.) Cif. & Red.

cc. Colonies whitish, yellowish or grayish in color.

d. Cellular elements aggregated in liquid media, producing a complete superficial pellicle.—*T. Lilienfeld-Toalii* Cif.

dd. Cellular elements not aggregated or only shortly chained, not producing a complete pellicle or without pellicle.

e. Cells chiefly ovate, colonies grayish, with lacerated borders.—*T. neotropica* Cif.

ee. Cells chiefly spheric, colonies white-yellowish, with linear borders.—*T. Hamel-Smithii* Cif.

aa. Cells generally apiculated or lemon-shaped.—(*Kloeckeria* Jancke.)

b. Cells large, fermenting levulose and glucose, not growing in pronounced acid media.—*K. domingensis* Cif.

bb. Cells smaller, fermenting glucose, growing in pronounced acid media.—*K. cacaoicola* Cif.

2. Multiplication by fission (*Schizotorulopsis* Cif.)
Only species.—*S. Bussei* Cif.

3. Multiplication starting by budding and ending by fission.—*Schizoblastosporion* Cif.)

a. White or whitish colonies, not liquefying gelatine, optimum temperature about 40–42°C. Cells small.—*S. domingensis* Cif.

aa. Yellowish colonies; liquefying, optimum temperature about 20°C. Cells larger.—*S. santhomensis* Cif.

II. With a true mycelium (*Mycotoruleae*).

1, With or without occasional arthrospores (*Mycotorula* Will.) One species.—*M. ramosa* (Saito) Cif.

2. Elongated or rectangular long chained arthrospores (*Geotrichum* Link).

a. Cerebriform-sulcate colonies, more or less woolly.—*C. cerebrinum* Cif.

aa. Pellicular, smooth colonies.—*G. flexuosum* Cif.

aaa. Cottony colonies, showing concentric rings and striae.

b. Colonies crenulated, not liquefying gelatine.—*G. byssinum* Cif.

bb. Colonies smooth, liquefying gelatine.—*G. byssinum* Cif. var. *rigidum* Cif.

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Explanation of Plates

Plate XXVIII. Loss in weight of fermented cacao and unfermented cacao exposed to the sunshine.

Plate XXIX. Increase in weight of fermented and unfermented cacao beans exposed to saturated water vapor.

Plate XXX. Increase in weight of fermented and unfermented cacao beans dried at differented temperatures and exposed to saturated water vapor.

Plate XXXI. Daily variations of weight of fermented and unfermented cacao beans in relation to the average of the atmospheric humidity.

Plate XXXII. Hourly variation of weight (increase and loss) of fermented and unfermented cacao beans exposed to the free air.

Plate XXXIII. Sketch of the Wilson's distillation box for the desiccation of the cacao beans.

Plate XXXIV. Five days record of a double recording thermograph, showing the temperature of the Wilson box as compared to the air temperature.

Plate XXXV.

Figure A. *Geotrichum byssinum* Cif. var, *rigidum* Cif. Old geant colony on malt extract gelatine (natural size).

Figure B. *Eutorulopsis theobromae* (Preyer) Cif. Adult geant colony on malt extract agar (natural size).

Figure C. *Schizosaccharomyces Bussei* Lil.—Toal & Henn. Old superficial vegetation on malt extract agar (one-half natural size).

Figure D. *Torulopsis Lilienfeld-Toalii* Cif. Adult geant colony on malt extract agar (natural size).

Figure E. *Geotrichum byssinum* Cif. Young but well developed superficial vegetation on malt extract agar (more than half natural size).

Figure F. *Torulopsis Lilienfeld-Toalii* Cif. Photograph of very young cellular aggregation on starting medium (very much magnified).

Figure G. *Geotrichum cerebrnium* Cif. Young colony on starting medium (about ¾ natural size).

Figure H. *Geotrichum byssinum* Cif. Young geant colony on malt extract agar (natural size).

Figure I. *Geotrichum byssinum* Cif. Old geant colony on malt extract agar (natural size).

Figure L. *Geotrichum byssinum* Cif. Young colony on carrot agar (natural size).

Figure M. *Geotrichum flexuosum* Cif. Very old geant colony on malt extract agar (natural size).

PLATE XXVIII.

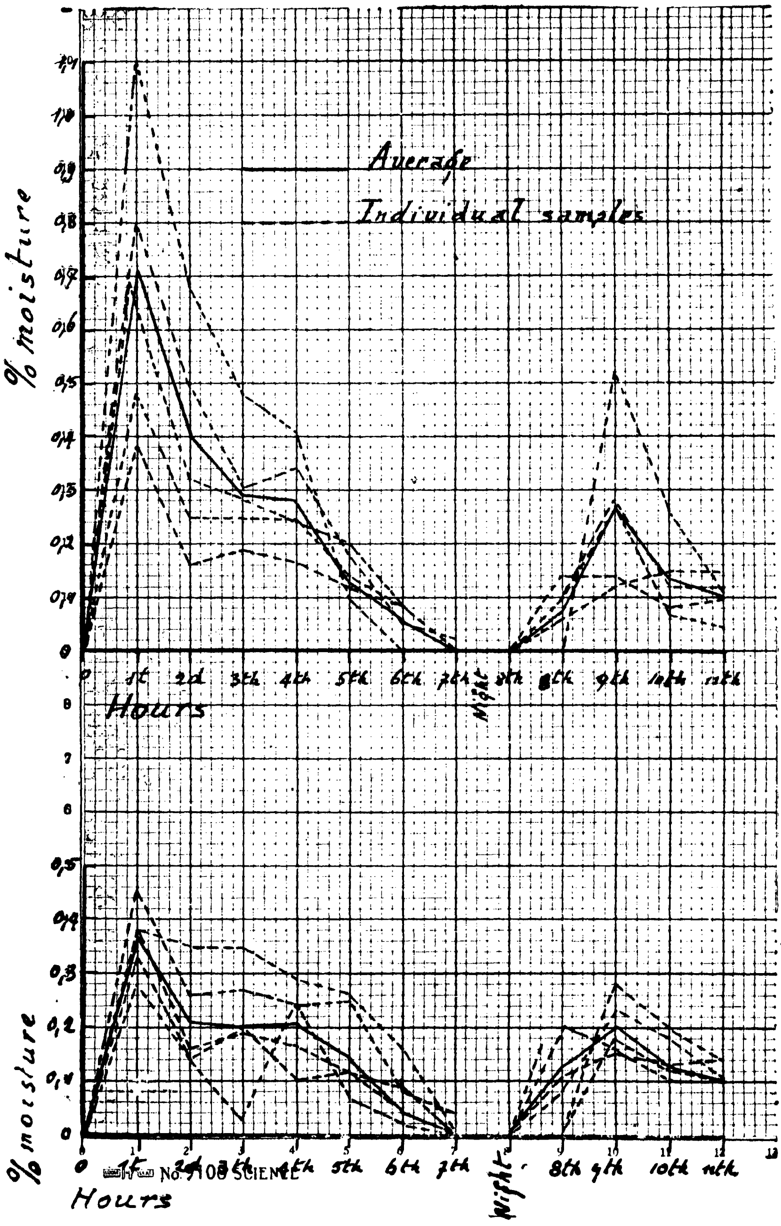
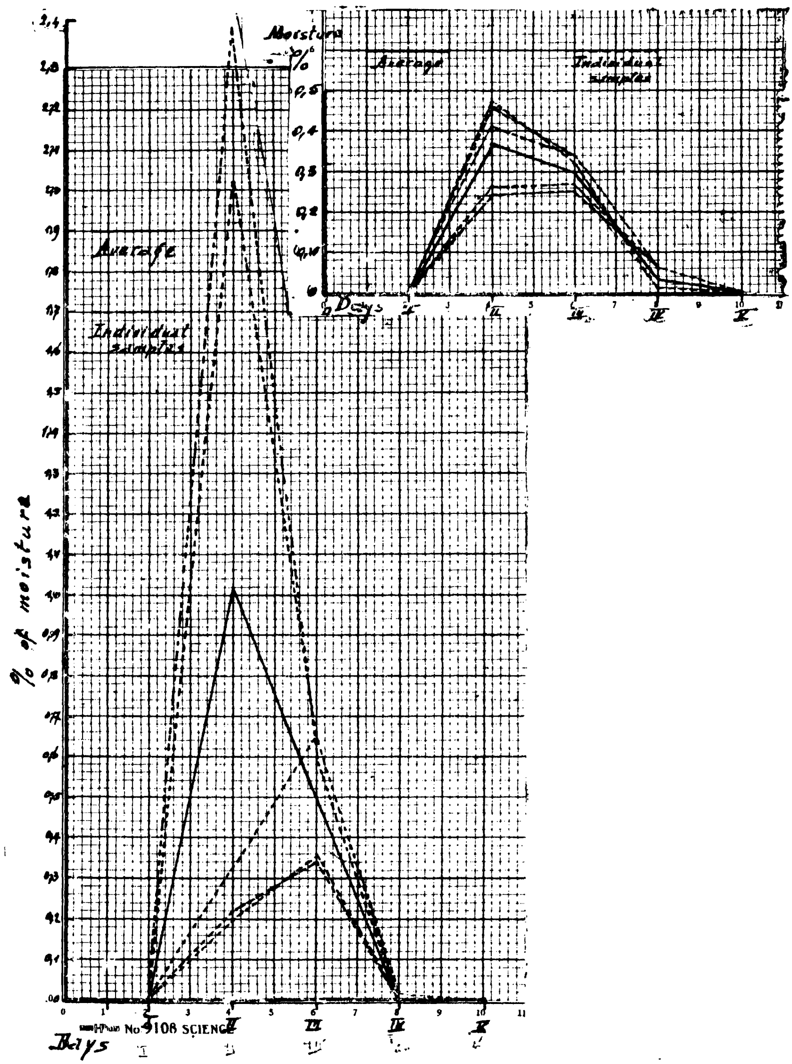


PLATE XXIX.



Moisture %
Average
Individual samples
% of moisture
Days
No 9108 SCIENCE

PLATE XXX.

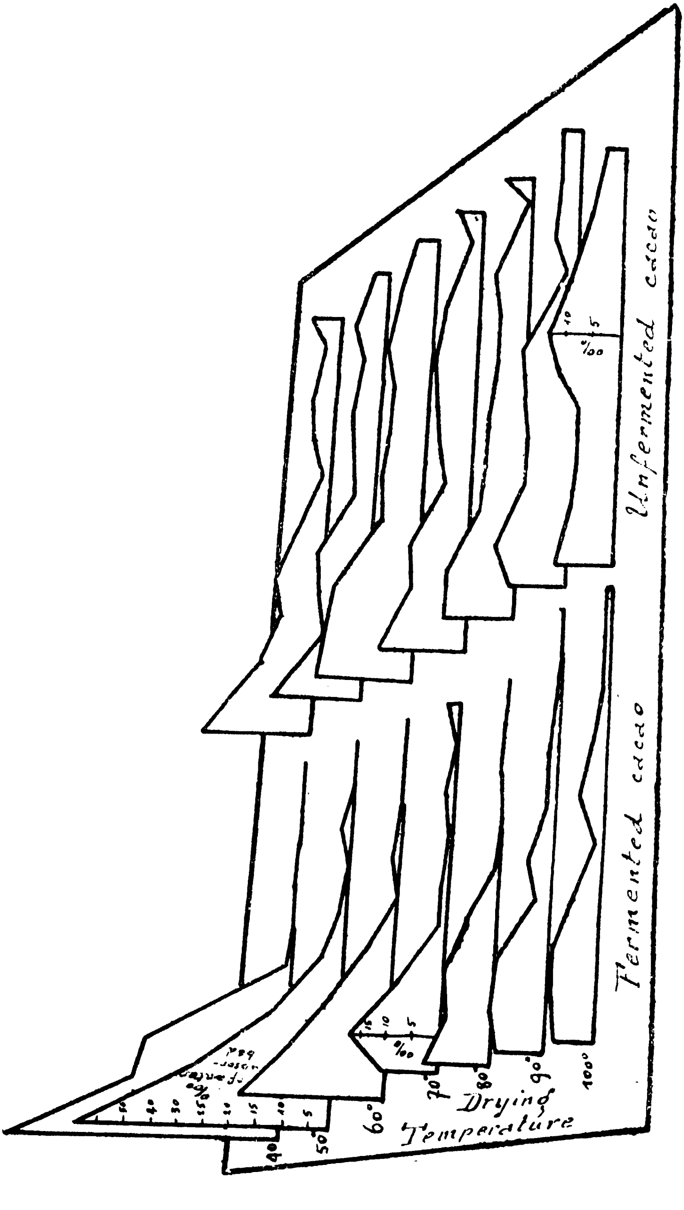
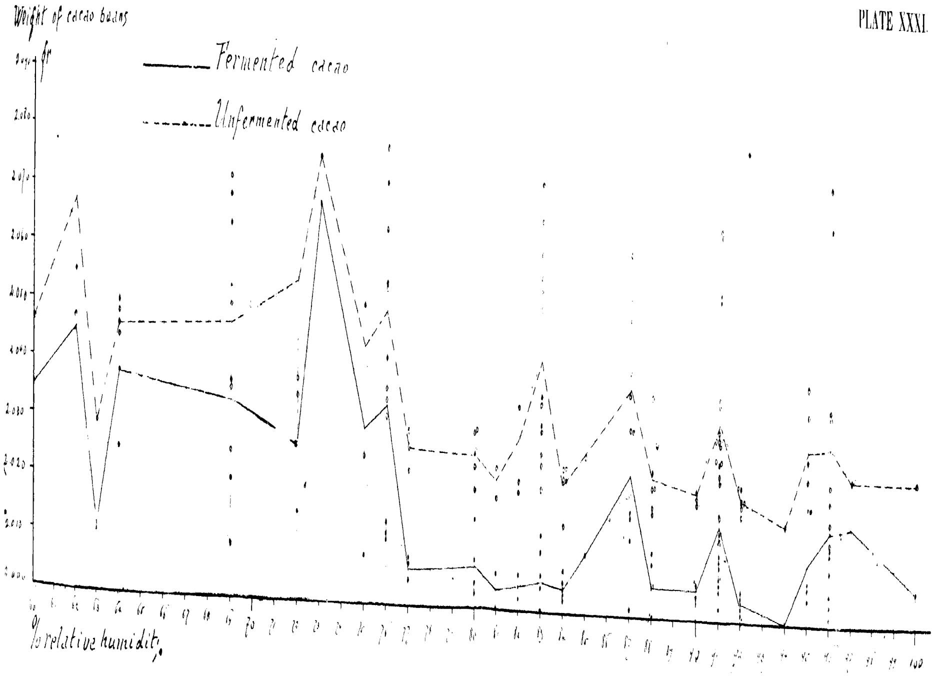
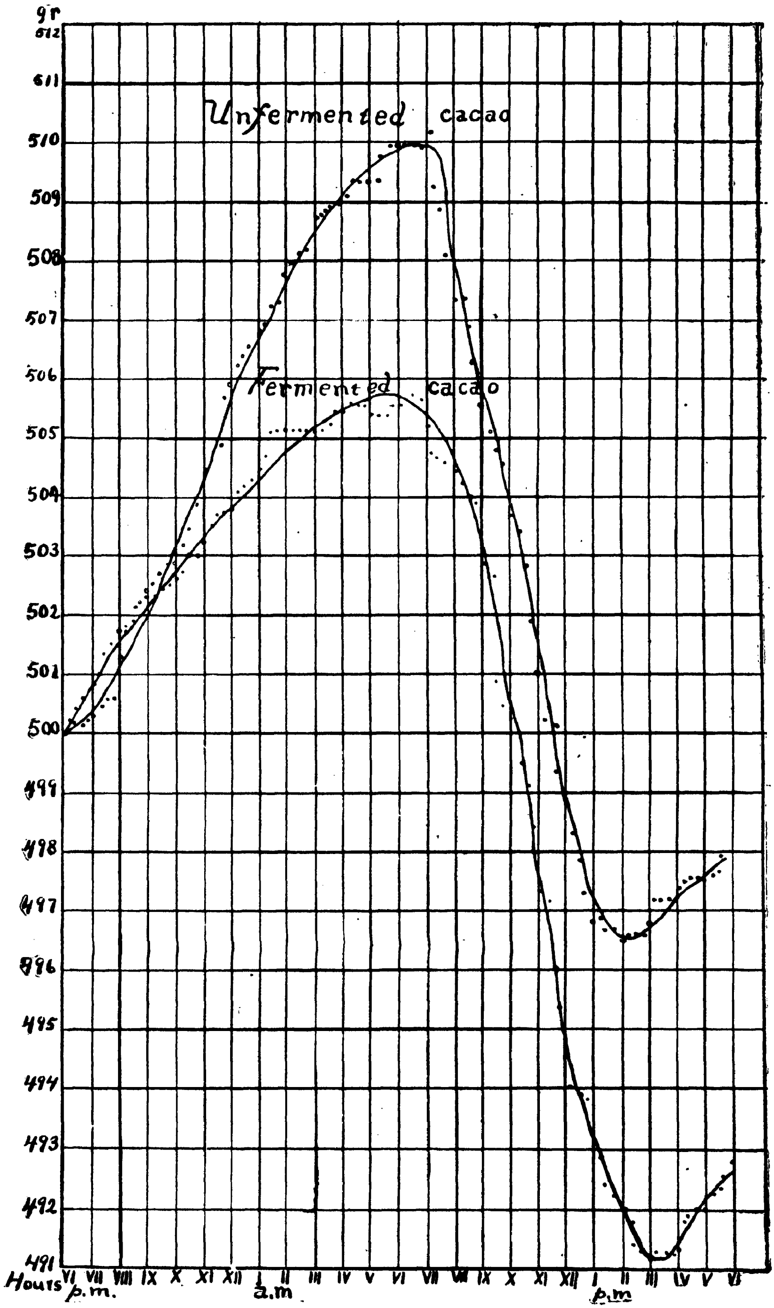

Unfermented cacao
Fermented cacao
Drying Temperature
40°
50°
60°
70°
80°
90°
100°
%/00

PLATE XXXI.



Weight of cacao beans
gr
Fermented cacao
Unfermented cacao
% relative humidity
100

PLATE XXXII.



gr
512
511
510
509
508
507
506
505
504
503
502
501
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499
498
497
496
495
494
493
492
491
Unfermented cacao
Fermented cacao
Hours
VI VII VIII IX X XI XII I II III IV V VI VII VIII IX X XI XII I II III IV V VI
p.m.
a.m
p.m

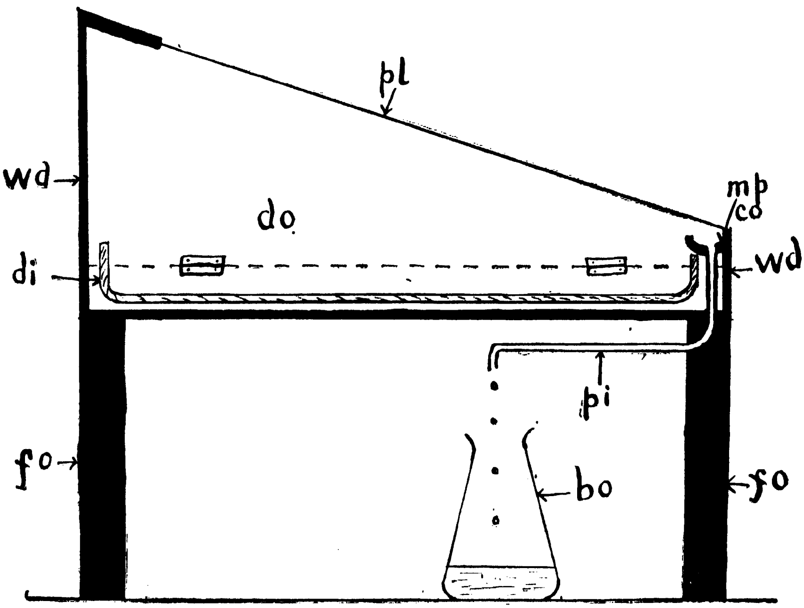
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PLATE XXXIV.

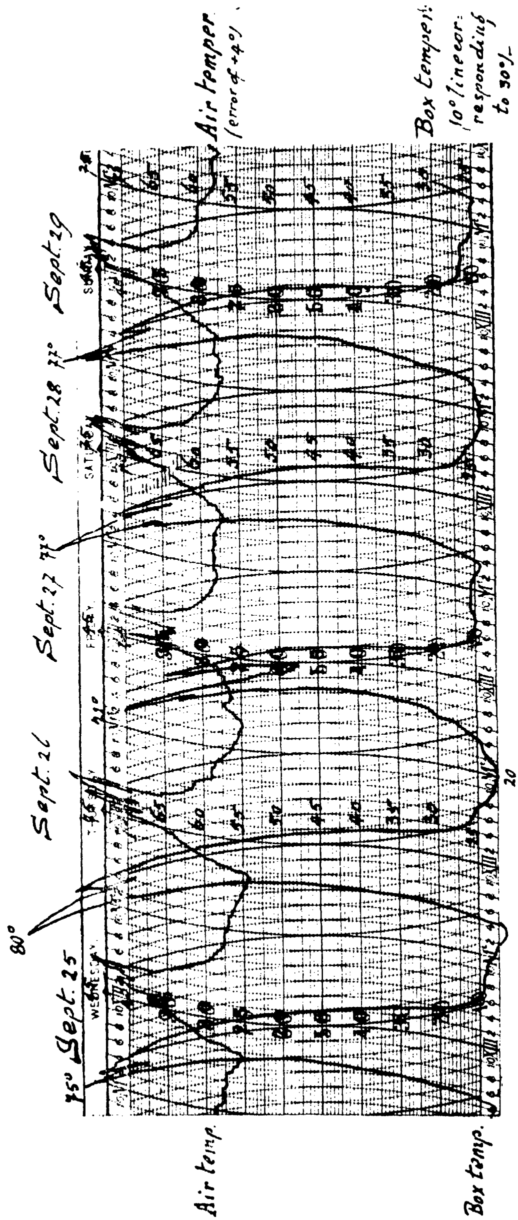
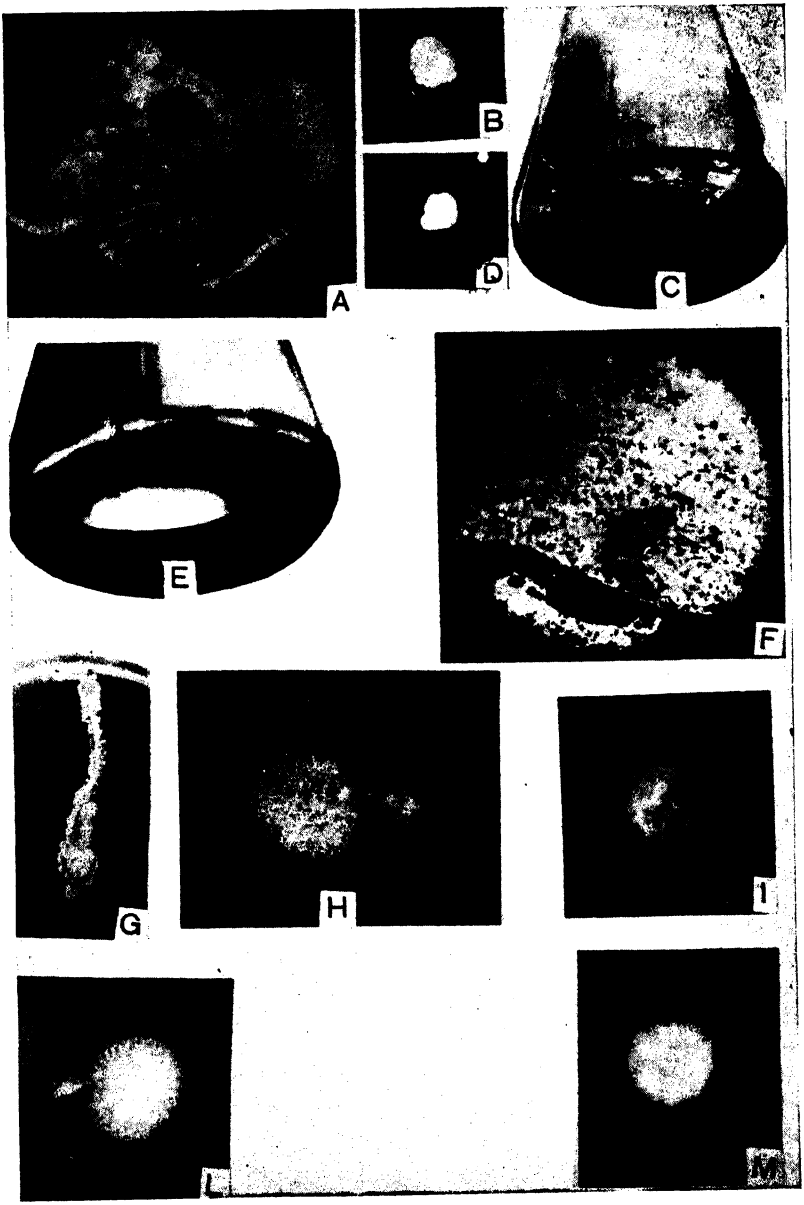

Air temper
(error of +4°)
Box temper:
10° line cor-
responding
to 30%
Sept. 25
Sept. 26
Sept. 27
Sept. 28
Sept. 29
80°
75°
77°
Air temp.
Box temp.

PLATE XXXV.



STUDIES ON THE BACTERIAL WILT OF THE SOLANACEAE IN PORTO RICO

J. A. B. NOLLA *

A bacterial disease of solanaceous crops has been prevalent in Porto Rico for many years, the first apparent report on the occurrence of this disease, having been made by Henricksen in 1906 (**3**). Outbreaks of this malady in solanaceous vegetable crops have been very severe. Since the demand for these crops had been limited to local consumption the importance of the disease was not fully appreciated until 1926 when shipments of tomatoes, peppers, eggplants and other vegetables began to be made to the United States. No sooner was planting of these solanaceous plants extended than the losses from this disease increased very materially. It was then recognized that, if the growing of tomatoes, eggplant and peppers was to be safeguarded against serious diseases, a study of the bacterial wilt was necessary. The writer was asked in the autumn of 1926 to undertake an investigation of the malady with special reference to its control. It is obvious that certain other points had to be studied to some extent in order to gain a better knowledge of the relations between the pathogen and its suscepts such as would clear the way for the all-important subject of control.

SUSCEPTS

VARIETAL SUSCEPTIBILITY

As a knowledge of the susceptibility of solanaceous crops is indispensable, preliminary trials were made in the growing season of 1926–27 with commercial varieties of tobacco, peppers, tomatoes and eggplant. The potato was added later, as information on the susceptibility of this suscept seemed important, since certain trials had shown it to be a promising new crop for the Island. Seed of all these crops was obtained from various sources in the United States.

The susceptibility of varieties of pepper, eggplant and tomato was determined by seed-bed tests and by studies in the field after transplanting. It was observed during the first year's work that the disease developed to some extent in the seedlings, especially on tomato and eggplant and to a lesser extent on pepper. The seed was

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sown in rows, four inches apart, in flats or beds. The soil used in these contained a large quantity of manure from a source known to be heavily infested with the wilt organism. As soon as any seedlings showed symptoms of the disease they were removed, a record being taken of the number of seedlings destroyed.

Seedlings were pulled from the seedbed when small, and planted in flats at a distance of four inches each way. Here they remained until large enough for transplanting in the field. The plants were removed with a ball of earth, reducing any temporary check in development as is the case when seedlings are transplanted without soil about the roots. A second advantage is that the seedlings suffer less and do not have the tendency to spindling growth, if for any reason transplanting is delayed. The less crowded condition helps in producing a hardier, stronger plant. A third advantage is the fewer chances of loss of seedlings during transplanting. It has been our experience that the mole-cricket attacks but few of the seedlings when they are transplanted according to this method.

The number of plants of each variety grown varied with the crop. The varieties were planted successively using four replications to reduce error.

Final counts were taken at the time when the second picking of fruit was made. Counts of diseased individuals in the seedbed and in the field are recorded together.

The results of incidence of the disease are given in the following tables.

TOMATO

TABLE 1.

INCIDENCE OF DISEASE IN COMMERCIAL VARIETIES OF TOMATOES, FIELD PLANTING

Variety	Population	Healthy	Diseased	% Diseased
Ponderosa	200	51	149	74.5
Pear Shaped Yellow	200	74	126	63.0
Gulf States	200	76	124	62
Louisiana Pink	200	79	121	60.5
Payne's Victory	200	83	117	58.5
Alameda Trophy	200	85	115	57.5
Early Detroit	200	89	111	55.5
Avon Early	200	91	109	54.5
Red Rock	200	94	106	53
San José Canner	200	94	106	53
Dwarf Champion	200	95	105	52.5
Maule's Matchless	200	102	98	49
Morse's Globe	200	102	98	49
Delaware Beauty	200	103	97	48.5
Bonny Best Early (Maule's)	200	104	96	48
Morse's No. 493, Special Early	200	109	91	45.5
Maule's Success	200	112	88	44
Marvana (U. S. D. A.)	300	188	112	37.33
Norton Wilt Resistant	300	189	111	37.0
Morse's Norton	300	192	108	36.0
Marvelosa (U. S. D. A.)	300	203	97	32.33
Morse's Marglobe	300	210	90	30.0
Stoke's Marglobe	300	218	82	27.33

From the above table it is clear that most commercial varieties of tomatoes are very susceptible to bacterial wilt. Ponderosa proved to be the most susceptible, almost three fourths of the population succumbing to the disease. Next in susceptibility is the Pear-Shaped Yellow (63 per cent) and the Gulf States (62 per cent). In a group ranging in susceptibility from 50 to 60 per cent, there are eight varieties. In a similar group from 40 to 50 per cent susceptibility, appear to fall six other varieties and between 30 and 40 per cent diseased plants there are four varieties. The least susceptible of the varieties were, in order of resistance: Marglobe (U. S. D. A.) (Plate XXXVI) with 23 per cent diseased plants; Marglobe (Stoke's) with 27.33 per cent, and Marglobe (Morse's) with 30 per cent diseased individuals. From the grower's standpoint a variety with a susceptibility higher than 30 per cent should not be recommended. It appears, that perhaps the Marglobe is the only tomato which may be grown with a reasonable degree of safety. It happens to be a good type, and the preliminary trials with it on the Island have shown it to be a good marketable tomato. Another tomato which proved to be somewhat resistant (32.33 per cent diseased) is the Marvelosa, distributed by the United States Department of Agriculture. It should be tested further.

A resistance test was also made of eight non-commercial Porto Rican varieties in order to locate resistant plants for breeding with varieties commercially desirable. Each one of these varieties was given a number in our records. They may be described briefly as follows: No. 1, small, about ½ inch–¾ inch in diameter, round; No. 2, slightly larger than No. 1; No. 3, pear-shaped, with longitudinal undulations, about 2 inches–3 inches long; No. 4, more or less oblong, about 2 inches × 1½ inches; No. 5, typically pear-shaped, small; No. 6, flat, large, so-called "platillo" (plate-like), much wrinkled; No. 7, flat, small, smooth; No. 8, flat and smooth, intermediate in size between No. 6 and No. 7.

Two hundred plants of each kind were grown. The symptoms of the disease appeared shortly after transplanting. The final data were collected in July, 1927. The results show that all plants died in all the strains except No. 6 in which 78.5 per cent were diseased.

It is evident that none of the native tomatoes are resistant and, therefore, are not to be used as material for breeding for disease resistance.

PEPPER

The results of tests with commercial varieties of pepper are given in table 2.

TABLE 2.

INCIDENCE OF DISEASE IN ELEVEN COMMERCIAL VARIETIES OF PEPPER.

Variety	Population	Healthy	Diseased	% Diseased
Early Giant	184	135	49	26.63
Ruby Giant	172	129	43	25.00
Tomato Salad	192	146	46	23.96
Large Bell	188	143	45	23.92
Neapolitan	185	143	42	22.70
Improved Ruby King	188	149	39	20.74
Crimson Giant	183	146	37	20.22
Ruby King	178	142	36	20.20
Chinese Giant	191	155	36	18.85
Worldbeater	189	154	35	18.52
Bull Nose Pepper	162	134	28	17.28

It will be seen that the populations are not uniform for the varieties, although 200 plants of each variety were set in the field. The reduction is due to injury by the mole-cricket to the seedlings which were not very large at the time of transplanting.

From the results given in the above table, it may be inferred that only Early Giant and Ruby Giant were heavily affected. However, the differences in susceptibility among the remaining varieties are not very significant. Three varieties Bull Nose, Worldbeater and Chinese Giant appear to have greater resistance than the others. Ruby King, Crimson Giant and Improved Ruby King are almost equally resistant.

Sixteen different forms of Porto Rican pepper were collected from various places in the Island and tested during the summer of 1927 in the same way as the imported commercial varieties.

Briefly described these forms are as follows:[1] No. 1, flat, wrinkled, hot pepper, about 1 inch in diameter; No. 2, hot, ovoid, 2 inches-2½ inches long, pointed at the blossom end; No. 3, long, large, hot, with a few longitudinal undulations; No. 4, "ají caballero", very small, hot, more or less conical and usually known as *Capsicum Baccatum;* No. 5, long, narrow, sweet, smooth, ends pointed, light green color; No. 6, Bull Nose type; No. 7, long, rather broad, angled, with blunt tip, about 6 inches long, light green color, sweet, so-called "Mallorquín"; No. 8, large, short, broad, almost as long as it is broad, dark green color, resembling the imported Chinese

[1] Descriptions for Nos. 10, 11, 12, and 14 are omitted. These forms were all nearly alike and similar to No. 9.

Giant, sweet; No. 9, a peculiar hot pepper with narrowed ends, broadened at about the lower third and pointed at the blossom end, purple toward the peduncle when not ripe, long peduncled, red when mature, so-called "ají platero" in Coamo; No. 14, a medium-sized sweet pepper with blunt tip, light green color; No. 15, rather long and broad, smooth, pointed abruptly at the blossom end, ratio of length to width 2:1, sweet; No. 16, extra long, sylindrical, hot pepper, so-called "ají picante" in Cayey.

One-hundred plants of each form were tested for resistance and the results are given below in the order of susceptibility: No. 6, 29 per cent diseased; No. 8, 27 per cent; No. 10, 23 per cent; No. 5, 21 per cent; No. 7, 21 per cent; No. 2, 19 per cent; No. 14, 18 per cent; No. 1, 17 per cent; No. 13, 17 per cent; No. 3, 16 per cent; No. 9, 16 per cent; No. 12, 16 per cent; No. 15, 16 per cent; No. 11, 15 per cent; No. 4, 12 per cent; No. 16, 12 per cent.

It is evident that the forms Nos. 6 and 8 are even more susceptible than the imported varieties given in table 2. These are, unfortunately, the two most desirable types in shape and size and the ones which would, therefore, offer the most suitable material for breeding work. The most resistant of the native forms are the hot peppers Nos. 4 and 16, both of which showed 12 per cent infection. A group with percentages of infection ranging from 15 to 19 includes forms Nos. 11, 3, 9, 12, 15, 1, 13, 14 and 2. These are given in order of relative resistance. Of the sweet peppers in the group the best in size and shape are Nos. 14 and 15. The remaining three forms, Nos. 5, 7, and 10 are undesirable; the first and third because of their shape and size and the second,—"mallorquín", because of its very light color and tender skin which does not stand much handling.

In general, it may be said that the hot peppers showed much higher resistance than imported sweet peppers, and that native forms of sweet pepper were not significantly higher in resistance than the imported varieties.

EGGPLANT

The following varieties of eggplant have been tested during the four-season period: six imported and five from the Island. Table 3, shows the relative susceptibility of each variety. The forms from Porto Rico are given in bold-face type.

TABLE 3.

INCIDENCE OF DISEASE IN IMPORTED AND PORTO RICAN VARIETIES OF EGGPLANT.

Variety	Population	Healthy	Diseased	% Infection
Black Beauty	500	72	428	85.60
Excelsior	500	85	415	83.00
New York Spineless	250	44	206	82.40
Large Round Purple	250	45	205	82.00
New Orleans Market	250	57	193	77.20
University Pink	250	69	181	72.40
Florida High Bush	500	152	348	69.06
Pompadour Purple Striped White	250	81	169	67.60
Long Purple	250	118	132	52.80
Camuy	500	444	56	11.20
Long Green	500	484	16	3.20

It is very evident that imported varieties of eggplant are extremely susceptible to the bacterial wilt and that, therefore, they can not be planted in infested soils without considerable risk. The varieties from Porto Rico are very resistant with the exception of "Pompadour" and University Pink. It is very unfortunate, however, that these resistant varieties do not possess the qualities of a commercial variety. The Long Green (Plate XXXVII) for instance, the most resistant of all (only 3.20 per cent infection) is a long, gourd-like green fruit and the "Camuy" (11.20 per cent infection), is a small, cylindrical purple fruit. The Long Purple, another form from the Island is of similar shape as the long green, but as will be seen from the table, it is quite susceptible to the disease.

The most susceptible variety was found to be the Black Beauty (Plate XXXVIII) with 85 per cent infection, followed closely by the Excelsior (83 per cent), New York Spineless (83.40 per cent), the Large Round Purple (82 per cent) and the New Orleans Market (77.20 per cent). Of the imported varieties, the most resistant appeared to be the Florida High Bush with 69.06 per cent infected plants, but it is doubtful if this variety can be successfully grown in infested lands on a commercial scale.

POTATO

Four varieties of potatoes of those which are being tested in the Island were planted in order to find out whether they were susceptible to the wilt. These were as follows: Bliss Triumph, Irish Cobbler, Green Mountain, and Spaulding Rose.

Twenty-five hills of each were planted in the field where the tests with eggplant, pepper, and tomato were conducted. The disease appeared on all varieties three weeks after planting and all plants were

infected by the sixth week. This experiment, although not dealing with a large population, indicates the high susceptibility of these varieties to the wilt, so that these potatoes should be planted here with this fact in mind. Infested fields should not be planted to potatoes.

TOBACCO

The following varieties of tobacco have been planted in infested land: "Virginia Blanco", the standard Porto Rican filler; "Ceniza"; "Vuelta Abajo"; a mammonth type labeled Station; Consolation (Yellow); Porto Rico Wrapper No. 1; "País"; Turkish; and two forms imported from Colombia, South America. Not a single case of the disease has appeared in any of the varieties. Wounding of the roots was practiced in order to increase the chances for the entrance of the causal agent. This was done by digging a number of plants of each variety when they were about a foot in height. The roots were then severely pruned and injured and the plants set again in their places. No cases appeared even with this treatment. It should be noted that in these experiments the susceptible Black Beauty eggplant was used as a check.

Another scheme was followed. Black Beauty eggplants which showed unquestionable symptoms of the wilt were dug out and tobacco plants set in their place. Even in this case the tobacco plants failed to become affected with the disease.

One hundred tobacco seedlings in pots and an equal number of plants about one foot in height, also in pots, were inoculated on roots, stems, and leaves. The cultures employed were isolated from eggplants and tomato plants. Six plants from the first lot became badly wilted, but a study of the lesions and a microscopic examination of them showed this wilting to have been caused by *Phytophthora Nicotianae*. All the remaining plants developed normally to maturity, bore seed, and when finally examined revealed no traces of injury by the inoculum.

From the above it seems that this bacterial wilt does not affect tobacco in Porto Rico.

INFECTION OF NORMALLY RESISTANT EGGPLANT VARIETIES

To ascertain whether normally resistant varieties of eggplant will contract the disease if artificially inoculated, a set of fifty plants of the Long Green variety was inoculated in 1928 with masses of bacteria oozing out of the vascular bundles of diseased Black Beauty

eggplants. Inoculation was made on tender twigs and on the woody stems by lifting the bark, injuring the woody tissues and transferring the inoculum into these wounds. Twenty-two of the fifty plants took the disease but it did not become generalized. From this experiment it appears that the disease may be induced on a normally resistant variety of eggplant through inoculation. The Long Green variety was shown in table 4 with a percentage of infection of only 3.2 while here 44 per cent have been infected.

RECOVERY OF DISEASED EGGPLANT

Recovery of diseased plants of resistant eggplant varieties has been found to occur. In the season 1929–30 it was found, for the first time, that a few plants of the Long Green variety which had been labeled as wilted or wilting had completely recovered. A closer inspection of the field was made and all plants that showed symptoms of the wilt were tagged on January 3, 1930. Bi-weekly observations were made recording the new cases of wilt or cases of recovery. The data collected up to March 9th. is as follows: out of 32 wilted plants, seven recovered and 25 died, a recovery of 21.89 per cent. Whether this may be expected in a larger population cannot be said. Similar counts with diseased Black Beauty eggplants were made and it was found that none of the wilted plants recovered. This would indicate that recovery takes place only in the resistant varieties.

GENERIC AND SPECIFIC SUSCEPT REACTIONS

It has been shown in the foregoing that the bacterial wilt of some solanaceous crops in Porto Rico severely affects eggplant (*Solanum Melongena* L.), pepper (*Capsicum baccatum* L., potato (*S. tuberosum* L.) and tomato (*Lycopersicon Lycopersicon* (L.) Karst.). The higher susceptibility of potatoes, tomatoes, and eggplant as compared to peppers is very clear from the data furnished in the preceding paragraphs.

Wilted zinnias (*Crassina Elegans* (Jacq.) Kuntze), were examined and an organism similar to or identical with that obtained from the eggplant, potato, and tomato, was isolated from them. A few cases of the disease on *Solanum torvum* L., a common weed, have been observed in the Station plots. The organism isolated from it is indistinguishable from that obtained from the aforementioned suscepts. The disease, however, is not very common on this suscept. The disease also occurs on the deadly night-shade (*Solanum Nigrum* L.).

Seaver and Chardón (6) list a wilt disease of solanaceous crops caused by *Bacterium solanacearum* E. F. Sm. and they evidently had in mind the same disease with which we have been dealing. *Solanum Wrightii* Benth., a recent importation from Panamá, has been repeatedly inoculated without success. Tobacco (*Nicotiana Tabacum* L.) has always failed to take the disease either through inoculation or under natural conditions. This is of particular interest in these studies because what is held to be the same disease occurs on tobacco in the United States where it is known as the Granville wilt. The same or a similar wilt is also found in many other tobacco countries.

Smith (l. c.) states that he received a report from Mr. Iorns, of Porto Rico, in which he held that *Solanum Mammosum* is resistant to what was, evidently, the disease under consideration.

The disease, then, appears to affect seven species of the higher plants, in four different genera from two families, the Solanaceae and the Carduaceae.

SYMPTONS

MORPHOLOGIC SYMTOMS

On the eggplant.—The first symptoms of the disease on eggplants are evident as a slight yellowing of the tender leaves of one or several shoots, followed by a severe wilting of these parts. The symptoms may appear on one branch alone or on several or may involve the whole plant. The period elapsing between the appearance of the first symptoms and the complete death of the suscept is usually from 7–10 days in the case of the very susceptible varieties like the Black Beauty, but it may be two weeks or longer in resistant varieties. In rapidly growing plants with abundant tender vegetative parts, the symptoms may have the appearance of lesions produced by scalding with boiling water or scorched by intense sun light.

On resistant varieties the symptoms may appear on one branch only which may be gradually killed while the rest of the plant remains healthy for a long time. Very frequently this is also affected. This is a very peculiar behavior of the eggplant, similar cases not being observed on any of the other suscepts. As discussed elsewhere in this paper a large proportion of the affected individuals of resistant varieties may recover from the disease.

In advanced cases the symptoms are those of the necrotic type, especially during rainy weather, when the tissues are overrun with

saprophytes. The leaves may show a rotting which invades the petiole and later the stem.

When plants are pulled and examined it is found that a large number of the roots have rotted, and upon lifting the cortex, a dirty white to creamy exudation, swarming with bacteria, is discovered.

On tomatoes.—The symptoms on tomatoes appear as a sudden wilting of the twigs and branches as in the eggplant. They resemble wilting produced by a cutting of the vascular bundles at some place below the wilted portion. They also resemble the condition resulting from attack by some sucking insects. The disease seems to start more frequently in the roots, which are much affected, and from there the organism works up the conducting system into the vegetative parts. Incipient roots are extensively developed on the stems of affected plants. It should be noted that this symptom has been reported for the same, or a similar disease, which occurs in other countries. Another symptom often observed, is a swollen condition of the stems. This has been reported by Smith (**8**) and others.

In the year 1927, during a very rainy season, some tomato plants showed a browning and rotting of the petioles of wilted leaves. Cankers were evident at the axils of the leaves. Isolations of a bacterium were made from the cankers and upon injection into healthy tomatoes, the characteristic wilting was produced, thus linking this symptom with the wilt. It is thought that the cankers were a result of the continuous rainy weather which helped to create a condition in the plant whereby they responded differently toward the organism. These symptoms were not repeated by inoculation, nor were they encountered in the succeeding seasons.

On peppers.—On this suscept the disease is characterized by a yellowing of the leaves at the margins. The discoloration may only include a few leaves, before the complete wilting of the plant occurs. Rolling or curling up of the yellowed leaves may occur, a symptom which has not been found on any other suscept. Peppers appear to be able to live longer than eggplant, tomato, or potato after the appearance of the first symptoms. Affected plants may gradually become defoliated before they finally succumb to infection.

On potatoes.—On the potato the disease is characterized by a yellowing of the leaves of young or immature shoots, or a sudden withering and death of stems and leaves. The disease spreads very rapidly in potato plants, one after the other succumbing to its ef-

fects. The symptoms in advanced stages are similar to those of plants which are undergoing a natural death.

In general, it may be said that the symptoms appear on the underground and all above-ground parts except the flowers and fruits.

HISTOLOGIC SYMPTOMS

Stems of all the suscepts show a browning of the vascular bundles which may extend from the roots to the petiole and main veins of the leaves. This browning of these tissues is very characteristic and is used in diagnosing the disease in those suscepts where morphologic symptoms are not very clearly defined. When infection begins on the leaves, the browning works down the veins into the midrib, thence down the petiole and into the stem. The bacteria which cause the disease are found massed in the vascular bundles and in great abundance in the stem in the region near the surface of the soil and in the roots. When either the affected roots or stems are cut transversely, the bacteria will ooze out in a short time in the form of a dirty white to creamy exudation.

In advanced stages the pith is also involved. In tomatoes and potatoes it soon breaks down into a soft mass; while in the egg-plant and pepper it is slowly decomposed, the stems retaining their rigidity and finally becoming hollow.

In potatoes the pathogen extends into the tuber, resulting in a browning of the bundles there as in the stems. Thus, when an affected tuber is cut transversely, a browned ring will be evident underneath the superficial cork layer. In large tubers which have recently contracted the infection the vascular ring is browned only a short distance beyond the stem end. If these are kept for a few days, however, the browning extends to the opposite ends and in still later stages a rotting of the tubers from the ring inwards with complete destruction is reached in ten to fourteen days.

ETIOLOGY

IDENTITY OF THE PATHOGEN

The identity of the pathogen causing the bacterial wilt of some solanaceous crops in Porto Rico has not been definitely established, although it has been referred to as *Phytomonas solanaceara* (E. F. S.) Com. S. A. B. (*Bacterium solanacearum* E. F. Sm), by Henricksen (**3**), Stevenson and Rose (**9**), Stevenson (**10**), Thomas (**11**), Ló-

pez (**5**), and Seaver and Chardón (**6**). It is interesting to observe that Smith (**8**) basing his opinion on tomatoes and eggplants received from this Island, regarded the disease identical with the brown rot of the Solanaceae which occurs in the United States and other countries. This is probably the first report of the disease in which the organism from Porto Rico was studied.

Suspicion that the pathogen might be an altogether different one was raised when Cook (**1**) reported that the organism causing a bacterial disease of eggplants at the Insular Experiment Station would infect tomatoes and peppers, but not tobacco, and also by the fact that the author also failed to get infection with it on tobacco.

The organism was isolated from various suscepts, cultural studies made, and cross-inoculations performed in an effort to further elucidate the problem.

CULTURE CHARACTERS

On nutrient glucose agar: A dirty white colony which produces a brown discoloration at the end of four to five days.

On steamed potatoes: A gray white colony producing pronounced browning.

On potato cylinders: A dirty white growth, staining the potato brown and causing a slow rot. The rotted portion becomes browned first and finally blackened.

On glycerin agar: Colonies dirty creamy to dirty white with only very slight browning.

On Litmus milk: Litmus is slightly reduced and curdling does not set in.

On milk: No curdling produced.

On nutrient bouillon (plus peptone): browning occurs and there is also some precipitation.

On peptone water: No browning.

On Dunham's solution: Pnorounced clouding.

On lactose agar: Growth dirty white producing much browning after eight to ten days.

No gas production was observed in fermentation tubes in peptone water or bouillon with the following sugars: dextrose, maltose, lactose, dextrine, laevulose, or saccharose. There was no clouding in the column of medium at the closed end of the tubes which indicates an aerobic organism.

The behavior on the above media was alike for the following cultures:

No. 1 and 4	From eggplant	Experiment Station 1926
No. 6	From eggplant	Manatí, 1926
No. 7 and 9	From tomato	Experiment Station 1926
No. 12	From tomato	Manatí 1926
No. 14	From zinnia	Experiment Station 1927
No. 18 and 19	From potato	Cayey 1927
No. 20 and 21	From eggplant	Cayey 1927
No. 24 and 27	From tomato	Experiment Station 1927
No. 28 and 30	From pepper	Experiment Station 1927
No. 33	From eggplant	Experiment Station 1928
No. 36	From *Solanum Torvum*	Experiment Station 1928
No. 37	From tomato	Experiment Station 1928
No. 38	From *Solanum Nigrum*	Experiment Station 1928

These cultures have been given in the order in which they were isolated. The irregularity in numbering is due to the fact that transfers were made and sub-cultures numbered before browning of the medium occurred and before the results of inoculations had been secured when a number of cultures were destroyed, thus accounting for the missing numbers in the series.

The organism proved to be gram negative.

From cultural characteristics alone it would seem that the organism that is responsible for the disease in eggplant, tomato, zinnia, potato, and pepper is probably the same.

PATHOGENICITY STUDIES

A large number of cross-inoculations have been made with the organism from the various sources. Considerable difficulty was experienced in this work since the organism appears to lose its virulence quickly in ordinary culture media and especially because the colonies from poured plates are similar during the first few days to those of non-pathogenic bacteria which also appear in the same plates.

The following scheme was at first adopted: plants were inoculated with the organism from the colony from which the subculture was made, usually five or six days after plating. The organism appeared to be virulent at this age. Later it was found that the organism retains the ability to infect its suscepts if it is carried in potato tubers or milk. The organism was most virulent when transferred directly from the affected parts to the plant to be inoculated. In this case the parts used for isolation were the bases of the stems, cut usually near the soil level. The portions of the stems were sterilized in mercuric chloride, after which the lower end was still further cut back with a sterile knife. These portions were then placed in sterile petri dishes, the bacterial ooze showing on the lower cut surface in a few minutes. Inoculations made with this ooze scarcely ever failed.

Almost invariably the inoculations were made on tender twigs or shoots at the axils of the leaves. It was only in the case of tobacco

that inoculations were made directly on the main stem, a few inches above the surface of the soil.

Infection through the roots was obtained merely by removing large plants from pots on which they had been growing, shaking out the soil around a few of the larger roots, wounding these and then planting in infested soil.

In every case the plants were cut after the wilt symptoms were evident and examined for browning of the vascular bundles, when the inoculations were pronounced as positive or negative.

The following varieties were used for inoculation Black Beauty: eggplant, "Mallorquín" and Ruby Giant peppers, Ponderosa tomato, and Porto Rico Filler tobacco. The potatoes were secured in the market and the variety is unknown.

The results are given in the following tables:

TABLE 4.

RESULTS OF INOCULATIONS AND CROSS-INOCULATIONS ON VARIOUS HOSTS—INOCULUM FROM FRESH COLONIES

Culture		Tomato		Eggplant		Pepper		Potato		Tobacco	
No.	Source	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.
1	Eggplant	6	0	6	0	4	2	5	1	0	6
2	Eggplant	0	4	0	4	0	4	0	4	0	4
3	Eggplant	0	4	0	4	0	4	0	4	0	4
4	Eggplant	4	0	4	0	4	0	4	0	0	4
5	Eggplant	0	4	0	4	0	4	0	4	0	4
6	Eggplant	4	0	4	0	3	1	4	0	0	4
7	Tomato	4	0	4	0	3	1	4	0	0	4
8	Tomato	0	4	0	4	0	4	0	4	0	4
9	Tomato	4	0	4	0	2	2	3	1	0	4
10	Tomato	0	4	0	4	0	4	0	4	0	4
11	Tomato	0	4	0	4	0	4	0	4	0	4
12	Tomato	4	0	4	0	3	1	4	0	0	4
13	Tomato	0	4	0	4	0	4	0	4	0	4
14	Zinnia	4	0	4	0	3	1	4	0	0	4
15	Zinnia	0	4	0	6	0	6	0	6	0	6
16	Zinnia	0	4	0	6	0	6	0	6	0	6
17	Zinnia	0	6	6	6	0	6	0	6	0	6
18	Potato	6	0	6	0	4	0	4	0	0	6
19	Potato	6	0	6	0	3	1	4	0	0	6
20	Eggplant	6	0	6	0	.....	.....	.....	.....	0	6
21	Eggplant	6	0	6	0	.....	.....	.....	.....	0	6
22	Eggplant	0	6	0	6	.....	.....	.....	.....	.....	.....
23	Eggplant	0	6	0	6	.....	.....	.....	.....	.....	.....
24	Eggplant	6	0	5	1	.....	.....	.....	.....	0	6
25	Eggplant	0	6	0	6	.....	.....	.....	.....	0	6
26	Eggplant	0	6	0	6	.....	.....	.....	.....	0	6
27	Eggplant	6	0	6	0	.....	.....	.....	.....	0	6
28	Pepper	6	0	6	0	6	0	6	0	0	6
29	Pepper	0	6	0	6	0	6	0	6	0	6
30	Pepper	6	0	6	0	5	1	6	0	0	6
31	Pepper	0	6	0	6	0	6	0	6	0	6
32	Eggplant	0	6	0	6	.....	.....	.....	.....	0	6
33	Eggplant	6	0	6	0	.....	.....	.....	.....	0	6
34	Eggplant	0	6	0	6	.....	.....	.....	.....	0	6
35	Eggplant	0	6	0	6	.....	.....	.....	.....	0	6
36	*Solanum Torvum*	6	0	6	0	6	0	.....	.....	0	6
37	Tomato	6	0	6	0	.....	.....	.....	.....	0	6
38	*Solanum Nigrum*	6	0	6	0	6	0	.....	.....	0	6
39	*Solanum Nigrum*	0	6	0	6	.....	.....	.....	.....	0	6

The results in table 4 show clearly that the pathogen in eggplant, pepper, potato, and tomato is identical. It is striking that in no

case did tobacco become infected, a total of 196 inoculations having failed.

TABLE 5.

RESULTS OF INOCULATIONS WITH OOZE FROM THE STEMS

Source	Eggplant		*Solanum Torvum*		*Solanum Wrightii*		*S. Nigrum*		Zinnia		Tobacco		Tomato	
	+	−	+	−	+	−	+	−	+	−	+	−	+	−
Eggplant..	24	1	0	36	0	24	12	0	6	4	0	36	12	0
Tomato...	24	0	0	24	0	24	12	0	8	2	0	36	12	0

When the bacterial ooze, both from eggplant and tomato, was used as inoculum, infection was obtained on tomato, eggplant, *Solanum nigrum,* and on zinnia. Tobacco, *S. Torvum* and *S. Wrightii* did not become infected.

TABLE 6.

RESULTS OF INOCULATIONS ON ROOTS

	Eggplant		Tomato		Pepper		*Solanum Torvum*		Tobacco	
	+	−	+	−	+	−	+	−	+	−
Wounded........................	22	0	22	0	11	1	1	23	0	24
Not wounded......................	39	11	41	9	28	22	0	24	0	50

From the results in table 7 it may be concluded that invasion through wounded roots takes place readily in infested soils, hence the practical conclusion may be drawn, that these solanaceous crops should be carefully cultivated so that the danger from disturbing the roots may be minimized as much as possible. The amount of infection in the different suscepts was as much as could be expected from susceptible varieties in a heavily infested soil. It is significant that tobacco did not succumb to the disease even when roots were heavily wounded. *Solanum Torvum* did not take the disease, except in one case, a result which is in harmony with that in table 5. This behavior of this wild suscept from which an organism similar in every respect to that recovered from eggplant, tomato, and the other suscepts was obtained, is rather peculiar. That a few plants were once infected by the organism, as must have been the case in the few individuals in which the disease was recorded and from which the organism was isolated, may have been due to a certain set of predisposing conditions within or without the plant or to great virulence of the invading pathogen. This is as far as we are able to explain. It is obvious that further studies on this suscept should be made.

LIFE HISTORY

The pathogen seems to live over in soils for a long time. In the Experiment Station grounds it has existed in the soil for at least ten years. This estimate is based on reports that the author has had from former horticulturists.

Plant remains from previous crops are an important source of inoculum. Manure has been found to be a carrier of the pathogen which appears to be able to live in it. The manure at the Insular Station has been shown to be infested with the organism, hence the infestation of all soils fertilized with it. The infestation of manure was proven by the following experiment. Six tin cans (5–gallon capacity) were filled with well-rotted manure, another six with soil known to have produced healthy eggplants and still a third series with a 1–1 mixture of such soil and manure. Healthy Black Beauty plants about six inches high were transferred with a ball of earth around the roots (these were slightly injured) to these cans which were kept in the greenhouse. All the plants grew to normal development until the first flower bud appeared, when two of those in the cans with soil and manure and three in those with manure alone showed unmistakable wilt symptoms. Three weeks later all the plants in the cans with either manure alone or with the mixture of soil and manure had contracted the disease. The plants in the cans with soil alone remained healthy to maturity.

Invasion occurs under natural conditions through leaves and roots. In plants which have been beaten strongly by the wind the lower leaves are much injured by the constant friction against the soil and it is these leaves which are often the first to be infected. Injured roots also provide entrance for the pathogen. As far as we have been able to ascertain the pathogen is only capable of invading plants through wounds. In the inoculation experiments given in the preceding paragraphs it would seem that this is not the case, because when plants were not injured a large number of them succumbed to the attacks of the malady. But it should not be forgotten that the roots of all the suscepts employed in these experiments were always subject to a certain amount of injury by animal pests.

In the experiment with manure in cans, where these soil inhabitants were obviated, the pathogen, no doubt, gained entrance through the wounded roots. By reason of unsuitable equipment we failed to conduct an experiment where these soil pests could be included.

During the growing season of 1929–30 the green beetle (*Diabro-*

tica graminea Baly) swarmed on our eggplants following which the disease appeared to extend considerably over a large field. In order to determine whether this insect was at all responsible for the dissemination of the pathogen a series of experiments was begun, using wire cages. Six healthy plants (Black Beauty eggplant) were covered with these cages. At the end of ten days they were examined and found to be healthy. The insects (*Diabrotica*), which had been fed for six days with twigs of diseased plants on which the leaves had wilted and the brown stain was evident, were then transferred to these cages, ten to fifteen to each cage. The insects were kept in the cages for two weeks when the first case of wilting was found in one of the cages. A second case appeared four days after the first and two more plants showed the disease twenty days after the insects had been transferred to the cages. Two plants remained healthy throughout the season. Six plants, also covered with cages, but from which the beetle was excluded, did not show any wilt symptoms. It may be concluded that *D. graminea* is a disseminating agent of the disease. (Plate XXXIX).

EPIPHYTOLOGY

The pathogen seems to attack most frequently plants growing in low, wet places, but the disease also appears on higher, well-drained locations. From our observations it may be inferred that the malady is more prevalent in heavy soils; nearly all the cases reported to us have come from sections having heavy soils. The disease is very severe in Río Piedras and in the Cidra-Cayey district where the soils are predominantly of the heavy class. But, in the sandy loams of the intervening section of Caguas no cases have ever been found by the writer or reported by others.

The appearance of the disease is in no way related to the age of the suscepts. We are inclined to believe that it coincides with certain seasonal changes, as for example, periods of continued rains followed by short periods of dryness. In our plantings the first cases were observed during one such rainy period following a dry season.

CONTROL

General eradicatory measures are always helpful in reducing the foci for inoculum and consequently furnish important means of control. However, they do not go very far in preventing heavy losses to our solanaceous vegetable crops. The removal of diseased plants is to be recommended but it must not be overlooked that the causal

agent lives in the soil in which it is capable of existing for a long time. A practical method of soil treatment which will kill the organism is desirable. But such a measure does not seem likely to be developed with our present knowledge of the malady. Preventive measures appear to us the most logical solution for the problem.

BREEDING FOR DISEASE RESISTANCE

The preliminary trials with varieties of eggplant, pepper and tomato, have made it clear that breeding for resistance is not promising for the latter two crops, since native and imported commercial varieties were more or less equally susceptible to this disease. Consequently, development of resistant strains in these must be sought through selection within the commercial varieties. On the other hand, some native varieties of eggplant showed a very remarkable superiority in resistance over any of the imported varieties. Unfortunately their shape, size and color are not suitable for the market thus making it impractical to extend their cultivation for commercial ends but they are suitable for crossing with desirable commercial sorts to secure desirable resistant plants.

Breeding work on tomato and pepper was not started by the author because he was engaged on other problems. It is only on the eggplant that he has endeavored to develop resistant strains.

Several crosses were made in 1926 between the imported susceptible varieties of desirable shape and color and those of Porto Rico showing decided resistance to the malady. Much progress has been made in this line and some of the results will be reported on later. Several strains which combine the desirable characteristics of both parents in each case, have been isolated and are under trial.

It was even thought that strains might be developed from the susceptible types. With this purpose in mind two selections in the Black Beauty variety were made in 1927. One of these was discontinued in 1928. That year two other selections were made from the one retained. Although in 1929 these did not show any higher resistance than the plants raised from imported seed, yet two further selections were made. These were given a final test in 1929–30 when they were abandoned because of their high susceptibility.

GRAFTING ON RESISTANT STOCKS

Grafting the eggplant on *Solanum Torvum* has been suggested by Ierns (4) for the control of diseases. Eighteen grafts of the Black beauty eggplant on *Solanum Torvum* were made in 1929–30 of which

only eight lived. The stock had been planted in our most heavily infested plots. All the grafts developed excellently without showing the symptoms of the disease. Of these plants five were destroyed by heavy winds, breaking the stems at the junction of stock and scion. The three remaining plants grew to maturity, bearing many fruits. They were then inoculated with ooze from Black Beauty diseased plants and all contracted the disease. This shows that as long as infection depended on invasion through the root system the plants were safe; but when the inoculum was introduced into the stems of the scion the disease developed. This seems to indicate that the stock has no influence on scion in respect to resistance.

GENERAL CONTROL MEASURES

Certain control measures which are always helpful should be enumerated here: (*a*) proper drainage of the land, (*b*) careful cultivation to prevent root injury, (*c*) care in transplanting to injure the least number of roots, (*d*) avoiding the use of manure which has given indications of being infested with the pathogen, and (*e*) avoiding, when possible, the heavier soils.

DISCUSSION

A bacterial disease present in Porto Rico on some solanaceous crops was considered as identical to that of the Southern United States for the first time by Henricksen (**3**) who based his conclusion on the similarity of the morphologic symptoms of the Porto Rican disease and that of the continent. Later the pathogen was determined as *Bacterium solanacearum* E. F. S. by Smith (**8**) who had received some diseased plants from Mr. Iorns of the Porto Rico Agricultural Experiment Station at Mayagüez. The disease has been subsequently attributed to Smith's pathogen, but no experimental work has been done previously in Porto Rico to prove that assumption. Cook (**1**) in 1924 raised the question of the identity of the eggplant wilt organism which he believed would not infest tobacco. The author has found that the eggplant organism will not infect tobacco but the disease produced by it on the other solanaceous crops is evidently very similar. Still the doubt remains as to whether it is *B. solanacearum* which is responsible for the disease, since this organism causes a wilt of tobacco in other countries. The fact that the organism isolated in Porto Rico from the other suscepts has never infected tobacco leads to the conclusion that either tobacco is resistant, or that the organism is distinct from *B. Solanacearum* or is a strain of it unable to infect tobacco.

The symptoms of the disease described elsewhere agree in every respect with those of the Porto Rican malady. The description given for *Bacterium solanacearum* E. F. S. is essentially that for the pathogenic organism isolated from the various suscepts. The organism is gram negative; it develops as white to dirty white colonies which produce a brown stain on many media, especially on sugar media; it loses its virulence very readily in most culture media but retains it in potato tubers and in milk; it does not curdle milk or reduce litmus; does not cause the fermentation of sugars and is aerobic. Although the writer admits that much more extensive work should be done with the pathogen before its identity can be definitely established, he is inclined to regard it as a strain of *B. solanacearum*. The only reason why it should not be considered as identical is the fact that tobacco is not infected by it. We think that, in all probability, we are concerned with a strain different from that occurring on the continent. A second possibility is that all tobacco in Porto Rico is resistant to *B. solanacearum*. In the final elucidation of the problem the tobacco from Porto Rico should be tested in the Southern United States, for instance, or the varieties from the continent should be introduced and exposed here to the pathogen. To conclude, we tentatively assign to the Porto Rican organism the rank of a strain which is incapable of infecting Porto Rican tobacco. Since the virulence of the organism is maintained only with difficulty it did not seem possible to obtain cultures from abroad for use in inoculating our tobacco.

SUMMARY

1. A bacterial disease of solanaceous vegetable crops has been prevalent in Porto Rico for many years.

2. The disease affects tomato, potato, eggplant, and pepper; *Solanum torvum, S. nigrum* and zinnias become infected occasionally, while tobacco appears to be immune.

3. All imported varieties of tomato, pepper, and eggplant are more or less susceptible. The Marglobe and the Marvelosa tomatoes and the Bull Nose, World beater, Chinese Giant, Ruby King, Crimson Giant and Improved Ruby King peppers are very resistant. The most resistant of the imported eggplants is the New Orleans Market. The most susceptible of all suscepts used are the Ponderosa tomato, the Early Giant and Ruby Giant peppers, and the Black Beauty eggplant. Four varieties of potato were found susceptible.

4. Peppers are more resistant than either eggplants or tomatoes.

5. Native varieties of eggplant are more resistant than the im-

ported sorts; but all native peppers and tomatoes are very susceptible. Hot peppers proved to be more resistant than the sweet peppers.

6. The disease is very severe on tomatoes and to a less extent on eggplants, at the seedling stage.

7. Normally resistant varieties of eggplant may contract the disease if artificially inoculated.

8. Some diseased plants of the resistant eggplant recovered from the disease.

9. The symptoms of the disease are characterized as a yellowing and withering of the tender shoots and leaves and finally a complete wilting of the affected plant. Sometimes lesions having the appearance produced by scalding water or scorched by strong sunlight are evident. Cankers are formed occasionally in tomatoes. Histologic symptoms consist of a browning of the vascular bundles.

10. The pathogen is culturally indentical with *Phytomonas solanaceara* (E. F. S.) Com S. A. B. *bacterium solanacearum* E. F. S. or very similar to it. In cross-inoculation studies it is also similar to it, but is unable to infect tobacco. We are of the opinion that it is only a strain of that pathogen.

11. The organism loses it virulence very readily on most artificial culture media.

12. Successful inoculations with the pathogen in culture were obtained when the inoculum was used directly from the original isolation on the poured plate. Inoculations with the bacterial ooze obtained in more or less uncontaminated condition from the vascular bundles of diseased plants scarcely ever failed.

13. Natural infection occurs through wounds in the leaves and roots.

14. The pathogen may be disseminated by the green beetle, *Diabrotica graminea* Baly.

15. The pathogen seems to be harbored in manure, plant remains, etc., and appears to exist in soils for a number of years.

16. It is believed that the first appearance of the disease coincides with periods of continued rainfall followed by periods of drought.

17. The production of resistant strains of the various crops seems to offer a logical means of control. Breeding work in the eggplant is in progress.

18. Grafting of susceptible varieties on *Solanum Torvum* only eliminates the chances of root infection.

The writer wishes to express his gratitude to Hon. C. E. Chardón,

former Commissioner of Agriculture and Labor of Porto Rico and to Mr. F. A. López Domínguez, formerly Director of the Insular Experiment Station, who encouraged and supported the work on this problem. He is also greatly indebted to Dr. Mel. T. Cook, Plant Pathologist of the Insular Experiment Station, for his helpful advice and criticisms and to Professors H. H. Whetzel, M. F. Barrus and W. H. Burkholder for help in the preparation of the manuscript.

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EXPLANATION OF PLATES

Plate XXXVI. A tolerant tomato plant at left and a susceptible (wilted) one at right.

Plate XXXVII. Upper. A susceptible variety of egg-plant.
Lower. A resistant variety of egg-plant.

Plate XXXVIII. An advanced case of wilt in the Black Beauty egg plant.

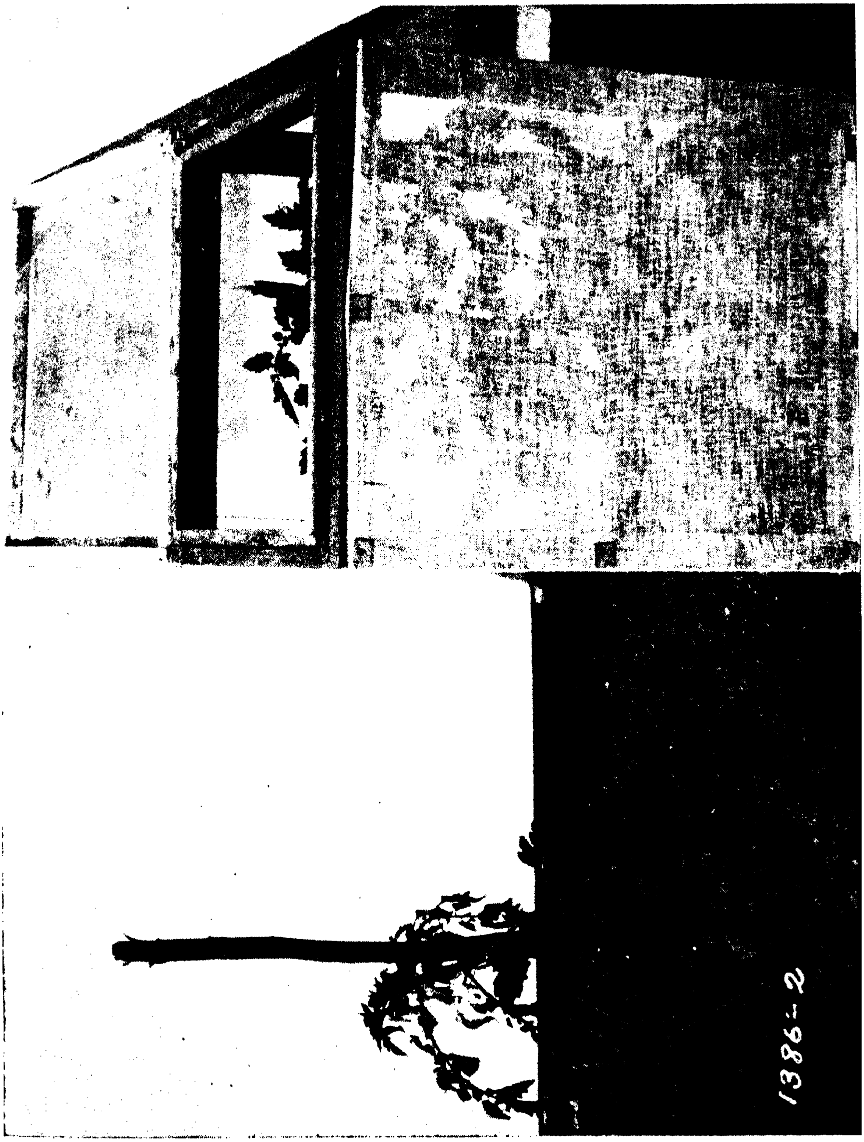
Plate XXXIX. At left—a wilted tomato plant.
At right—a cage used in the study of insect transmission.

PLATE XXXVI.

PLATE XXXVII.


9-28

PLATE XXXIX



OBSERVATIONS ON THE BEAN LACE-BUG IN PORTO RICO

By Mortimer D. Leonard[1] and Alfred S. Mills[2]

SYSTEMATIC HISTORY

Corythucha gossypii was first described by Fabricius in Ent. Syst. **4**, p. 78, 1794 as *Acanthia gossypii* from the island of Dominica in the West Indies. The species has been subsequently mentioned in systematic literature by Latreille, Burmeister, Herrich-Schaeffer and Fieber, all of whom placed it in the genus Tingis. Stal in 1869 referred it to the genus Galeatus but in 1873 placed it in the genus Corythucha where it has since remained.

DISTRIBUTION AND FOOD-PLANTS

The bean lace-bug has been recorded from Mexico, New Mexico, Texas, Florida, Central America, from Venezuela in South America and from the West Indies. In the latter it is the most common and widely distributed member of the genus Corythucha, feeding upon several different plants not closely related botanically. It has also been recorded from New York and New Jersey, but according to Barber and Weiss (5) and confirmed by Drake's extensive studies, it does not occur north of Florida. Records from these two states should probably be referred to *C. marmorata* Uhler.

There follows the detailed distribution data:

Mexico.—In the United States National Museum this species is represented as follows: Specimens from the Uhler collection labelled "Mex."; several from Durango, Feb. 1918; one from Tampico, 1918; Aguas Calientes, one collected by E. A. Schwarz and many specimens collected by F. C. Bishopp, Dec. 1, 1909.

Ferris (16) found the insect in some numbers on castor beans (*Ricinus communis*) at San José del Cabo in Lower California and Dr. Drake also has material from Lower California. Van Duzee (36) records it from San Carlos Bay, State of Sonora, July 9, breeding in immense numbers on Palo San Juan; also on Coronados Islands, May 18, and on San Esteban Island, April 20. He states that the food-plant is *Atamisquaea emarginata*.

Dr. Alfons Dampf in a letter dated Feb. 7, 1931 to Dr. C. J. Drake states that this lacebug "appeared in enormous quantity on

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castor beans (*Ricinus*) sucking the leaves and spoiling the harvest. According to the proprietor the bugs attacked nearly 60 hectares (150 acres) of this plant on the Hacienda El Palmar, between Jalapa and Vera Cruz, State of Veracruz, 700 meters above sea-level."

NEW MEXICO.—Dr. Drake writes that he has one specimen labeled "New Mexico". The United States National Museum has one specimen from the Uhler collection from castor oil without definite locality.

TEXAS.—Victoria, Dec. 1, 1909, F. C. Bishopp coll. and May 29, 1913 Mitchell and Coad coll. (United States National Museum.)

FLORIDA.—Recorded by Osborn and Drake (25) on *Ichthyometia (Piscidia) piscipula,* by Watson (37) as injurious to castor bean, and by Blatchley (6) from "Cape Sable and Marco, Feb. 20–Mar. 9, taken by sweeping Hibiscus and other plants along the margins of tidewater bayous. Recorded from Biscayne Bay and Miami." Dr. Drake writes us that he has specimens in his collection from Key West, Miami, Sebring, Gainesville, and Sanford. The United States National Museum has material from Silver Palm, May 15, 1923 (G. F. Moznette collector).

HONDURAS.—Drake (13) records it as extremely abundant near Tela and considerably injuring sour sop (T. H. Hubbell collector).

GUATEMALA.—The United States National Museum has 2 specimens from Pantaleon, 1,700 ft. Champion coll, which were recorded as *C. decens* in Biologia Cent. Am.

COSTA RICA.—In the United States National Museum are several specimens from *Prunus persica,* Dec. 19, 1913, without definite locality.

PANAMA.—In the United States National Museum many on Jatropha sp. from Bella Vista, Oct. 28, 1918 collected by Dietz and Zetek. Dr. Drake wrote under date of June 11, 1931 that he had recently received material from Mr. Zetek from the Canal Zone who stated that the insect was feeding on beans.

JAMAICA.—Gowdey (19) listed the insect as a pest of Congo pea (*Cajanus indicus*) and of Hibiscus. The United States National Museum has 2 specimens from Kingston. Van Duzee (33) lists it from Kingston, Mandeville and Montego Bay.

CUBA.—Drake (12) recorded several specimens having been taken at Guines, March 18, 1925, by Dr. J. G. Myers on castor bean. The United States National Museum has specimens taken on castor oil from Santiago de las Vegas (P. Cardin coll.) May 1918 and San Antonio de los Baños, April 1918. Bruner (7) records it as found

locally (Aug. 13, 1925) breeding on leaves of citron or cidra (*Citrus medica* L.) but not important as a pest of this plant.

HAITI.—Although the insect has apparently not heretofore been recorded from Haiti we have the following statement from Dr. H. L. Dozier, Chief Entomologist of the Department of Agriculture in Haiti under date of March 17, 1931 in which he says "it is common and very abundant, widely distributed everywhere in Haiti on beans and on 'bois cabrit' (*Cassia emarginata*)." Dr. Wm. A. Hoffman collected 1 specimen at Plaine Cul de Sac, Dumai, April 22, 1925 (United States National Museum).

SANTO DOMINGO.—Many specimens in the United States National Museum from La Romana Central, July 15, 1917, collected by H. Morrison.

PORTO RICO.—The insect is undoubtedly widely distributed in Porto Rico although it is possible that it is confined for the most part to the lower altitudes, not having been recorded as occurring higher than about 1,300 feet (at Cayey).

We have the following definite records mostly from notes in the Insular Experiment Station and from our own observations: in the north part of the Island from Pt. Cangrejos on sword bean (Wolcott coll.), 1912 and on beans 1925 (United States National Museum); Camuy, scarce on cotton, 1921; Río Piedras, on sword beans, (*Canavallia spp.*) March 1912, Wolcott coll. (United States National Museum); Ciales, on castor bean, 1913; Palo Seco on about two acres of pole lima beans and on several papayas during August, 1930; Río Piedras on lima bean, sour sop (*Anona muricata*) and on *Anona diversifolia* Safford, castor bean and papaya in 1930 and 1931; Mameyes on yautía, 1912; Luquillo on castor bean 1916; Dr. G. N. Wolcott found several young lemon and orange trees moderately infested in April 1931 at Isabela and the writers early in May made the same observation on young grapefruits at Río Piedras; material in the Drake collection also from Mayagüez; in the south part of the Island from Yauco, scarce on cotton, March 7, 1930; between Yauco and Guánica (Hacienda Santa Rita) on lima beans, badly infested August 21, 1930; Hacienda Santa Rita in Drake collection; Tallaboa, moderate on castor beans, August 21, 1930; Ponce, quite abundant on papaya, July 30, 1930; Guayama, on lima beans, 1917; and Cayey, (about the middle of the Island) quite abundant on papaya, August 2, 1930. We have also found the insect moderately abundant in April and July on castor bean on Vieques Island both at Puerto Real near the west end and at Salinas on the east end.

VIRGIN ISLANDS.—Wilson (40) reports the castor bean infested with this species on the islands of St. Croix, St. Thomas, and St. John. The same writer (41) also states that *C. gossypii* is a minor pest of cotton in St. Croix but seriously injures castor beans. We also found it abundant and very injurious in several garden patches of lima beans on the island of St. Thomas on August 11, 1930.

ANTIGUA.—Several specimens in the United States National Museum from castor oil plants on August 19.

MONSERRAT.—Ballou (1) stated that "a small patch of cotton was attacked by *Corythucha* the foliage of the plants being affected like that of castor oil plants attacked by the same insect." There seems to be no doubt that this refers to *C. gossypii*.

ST. VINCENT.—Watts (38) says "*Corythucha* has been noticed feeding on cotton leaves. This is apparently the same insect as that recorded from Monserrat." In Rept. Dept. Agr. St. Vincent for 1919 (39) it is stated that "the Corythucha bug was severe on castor oil plants grown at the experiment station during the year." Wilson (41) states it to be a minor pest of cotton. The United States National Museum has material collected by H. H. Smith on the "windward side."

GRENADA.—"Grenada" (Drake collection). There is also material in the United States National Museum collected by H. H. Smith from the Mount Gay Estate (leeward side.)

TRINIDAD.—Urich (32) records finding that a "Tingitid, *Corythucha* near *ciliata,* also found on the castor bean, seems to have a liking for dahlias, the leaves of which plant it soon causes to wither". Specimens are in the United States National Museum from castor bean from "Trinidad" collected by F. W. Urich, May 20, 1893 and several collected by W. E. Broadway, Oct. 14, 1908.

VENEZUELA.—Several specimens in the United States National Museum from Caracas collected by A. Ernst, Sept. 23, 1886.

Dr. Drake writes that he believes more collecting will greatly extend the distribution of this species in South America.

ECONOMIC IMPORTANCE

Judging from our own observations and records in literature this insect is by far more injurious to lima beans than to any other of its known food-plants. It has however, apparently not been recorded as attacking lima beans in any place but Porto Rico and the only previous mention of injury to this crop is by Wolcott at Guayama (1916) and by Smyth (1920). On August 11, 1930 a small

patch of lima beans at Charlotte Amalie in St. Thomas was observed to be badly infested. On August 21, 1930, we saw a small patch of lima beans at the Hacienda Santa Rita between Yauco and Guánica also badly infested. On August 29, 1930, we visited a grower at Palo Seco, across the bay from San Juan, who had over two acres of pole limas and string beans, the leaves of which were so badly damaged that practically no pods had formed, although the plants were all old enough to have been in full bearing. This grower stated that he had been troubled by the pest for several years and that it was more injurious during the summer, being the main reason why more lima beans were not grown during that season of the year. During the early part of September a severe infestation was observed on a fair sized garden patch of pole limas at Río Piedras on which pod formation had been almost entirely prevented. Two or three miles distant another younger planting which was just starting to blossom was beginning to show the start of an infestation.

It should be mentioned that in September, 1930 a bearing planting of bush limas at Cidra at an altitude of about 1,300 feet showed no infestation and the grower stated that although he had previously grown beans they had never been bothered by the pest.

As is well known the characteristic injury of lace-bugs is caused by the feeding of the nymphs and adults on the underside of the leaves from which they extract the juices. Where only a few insects are present a slight whitish discoloration of the upper surface is apparent, but as they become more numerous the whitish areas are greater in extent until in severe cases the whole upper surface of the leaf is involved. In some cases the entire surface may be mottled with darker spots and if sufficient feeding has taken place the leaves finally turn brown, wither, and fall off. The under surface becomes spotted and discolored with excrement (Plates XL and XLI). We have noted cases of such severe injury only to lima beans and to the four trees of *Anona diversifolia* on the Insular Experiment Station grounds mentioned above.

These Anona trees, about five years old, were introduced from Guatemala when about a year old and are about 8--12 feet high. By October and November 1930 the leaves were severely injured and many had dried up and fallen to the ground. By March 1931 these trees had set a new crop of healthy leaves and the lace bugs were scarce. In the case of beans the size and quality of the pods has been reduced or their formation almost entirely prevented. Injury that we have observed to other plants such as cotton, papaya, sour

sop and citrus has been confined mostly to comparatively small whitish areas on the upper surface of the leaves, altho the grower in Palo Seco where the severe injury to lima beans was observed, stated that twice in the past several years he had experienced considerable injury to his papayas.

LIFE HISTORY AND HABITS

The bean lace-bug may be found breeding on its various food-plants at all times of the year in Porto Rico. Breeding is continuous and rapid and although the exact length of time needed to complete a generation has not as yet been definitely determined it is apparently not more than about three weeks.

The eggs are laid on the underside of the leaves and are partially inserted into the leaf tissue usually along the midrib but are sometimes laid along the larger veins. They are often deposited within the tissue of the midrib or of the veins. As usual they are surrounded by a mass of black gummy substance which leaves only the cap slightly projecting or which may sometimes almost entirely cover the cap, but frequently eggs may be found projecting a considerable part of their length. A great many eggs may be laid upon a single leaf.

The nymphs usually feed in fairly compact clusters frequently in company with one or more adults. Both nymphs and adults are readily disturbed and the colonies tend to scatter when the leaf is turned over for examination.

DESCRIPTION OF STAGES

THE EGG.—(Fig. 1.) Length, .33 mm., greatest width, .15 mm.; flask-shaped with the neck bent somewhat to one side; anterior end obliquely truncate and provided with an oval lid which has a submarginal ridge enclosing a somewhat depressed area; the posterior end rounded; the chorion without sculpture, smooth and shining, the posterior half whitish, the anterior half blackish with the line between the two colors sharply defined

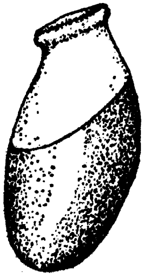

Fig. 1.—Egg greatly enlarged.

FIRST STAGE.—Length .4 mm.; upon hatching from the egg the nymph is at first pale greenish but the abdomen soon becomes somewhat darker green due to ingested food and the head and thorax become slightly tinged with brownish; body noticeably cylindrical as compared with the more flattened shape of the

later stages; antennae only about one third the length of the body and three segmented, last segment with several prominent hairs especially at the tip; eyes consisting of five prominent bright, red ommatidia; a median pair of moderately long black hairs near the front and a pair of longer black hairs on either side on the vertex between the eyes and the median line, each of the latter pair arising from a prominent tubercle; thorax only a little wider than head and with sides almost parallel, slightly brownish along the lateral margin. Pro- and meso-thoracic segments and abdominal segments two to nine with a dark lateral hair and in addition on the meso-thorax there is a median pair; abdominal segments five and six each with a pair of prominent black hairs either side of the median line arranged so as to form a transverse row, segment eight with a pair of median hairs somewhat shorter, each arising from a rather well-defined tubercle and just in front and inside of these, two somewhat shorter black hairs; legs pale yellowish, beak concolorous, with extreme tip distinctly blacker.

Second Stage.—Length .6 mm.; body somewhat more flattened than in first stage and abdomen somewhat more explanate, coloring about the same as in the first stage except that segments four to six of the abdomen contain a little brownish pigment: head with two pairs of simple anterior hairs present in first stage now shorter and arising from an elongated protuberance, the anterior pair of hairs on the vertex also now arises from a prominent blackened conical protuberance, the other pair remaining simple and arising just caudad at their base: thorax distinctly wider than head: the two pairs of lateral hairs on the meso- and meta-thorax are now also much shorter and arise from a darkened conical protuberance; the meso-thorax has a pair of darkened conical protuberances ending in a short hair and from the base of each arise two simple hairs; the lateral margin of abdominal segments two to nine each with a pale prominent conical protuberance ending in a fine black hair and with a fine black hair arising on the base of each protuberance on abdominal segments two to seven; the two pairs of median black hairs on segments five to six remain the same as in the first stage except that they are shorter but the posterior pair on segment eight is now elongated into two conical protuberances.

Third Stage.—Length .85 mm.; body considerably more flattened than in preceding stage with the lateral margin of the thorax and abdomen distinctly upturned; head, lateral margins of thorax broadly, and disc of abdominal segments four to six more distinctly

brownish than in preceding stage; conical protuberances on head considerably larger than in preceding stage, dark brownish and the posterior pair of the two cephalic hairs now both arising from a single base which is considerably elevated; thorax with the lateral conical protuberances of the pro- and meso-thorax more prominent than in preceding stage especially those on the meso-thorax; just in front of each is now a small setigerous tubercle and near the base of each two small black hairs; there is a median pair of small hairs on the pro-thorax; abdominal protuberances and hairs appear to be about the same as in the preceding stage except that the second segment now has a pair of pale conical protuberances.

FOURTH STAGE.—Length 1 mm.; number of ommatidia considerably increased, wing pads now distinctly formed, dark brownish, and reaching almost to second abdominal segment; antennae still seem to be but three-segmented; conical protuberances the same as before but those especially on the head and thorax proportionately larger; there are now two pairs of small median hairs on the pro-thorax; general color of body tending to be a little darker yellow with the brown of the pro-thorax confined to a subquadrate patch on either side of the median line in front and a transverse patch just in front of each wing-pad; the abdomen is now distinctly darkened toward the tip and the antennae are slightly infuscated toward the tip.

FIFTH STAGE.—Length 1.5–1.7 mm.; differs chiefly from the preceding stage in the following particulars: eyes have more ommatidia, pro-thorax wider and produced behind into a rounded point on the median line; wing-pads reaching backwards to the fifth abdominal segment and with a prominent lateral angle towards the front; armature on each caudo-lateral angle of pro-thorax consists of two spines, one longer than the other, and a simple hair all arising from a single tubercle; the lateral border of the wing-pads near the middle now has two prominent conical protuberances and a simple hair arising from a common tubercle, second abdominal segment with a pair of median whitish spines tipped with a short fine black hair; the brownish coloring is approximately the same as before on the head, pro-thorax, and abdomen but only the tip and base of the wing-pads are now darkened; antennae now four-segmented.

ADULT.—(The following description has been prepared for us by Dr. Carl J. Drake.) Size variable, usually about 3 mm. long and 1.6 mm. wide. The pronotum pale brown; reticulations white

and marked with brown or fuscous; areolae hyaline. Hood moderately large, slightly contricted behind the middle, rather closely reticulated, more or less marked with brown or fuscous, its length equal to one-half its width. Median carina strongly foliaceous, distinctly arched, subequal to length of hood, mostly biseriate, with a large brown or fuscous spot; lateral carinae rather short, small, raised anteriorly, terminating at base of triangular projection of pronotum, composed of one triangular areola. Antennae testaceous, segments III and IV with numerous long bristly hairs. Bucculae open in front. Mesosternum strongly sulcate, the rostrum extending behind the intermediate coxae.

Body beneath brown to fuscous; legs testaceous. Elytra with sides slightly concave, with distinct tumid elevation, the areolae somewhat variable in size; markings variable, sometimes almost wanting, usually forming two or three interrupted transverse brown to fuscous streaks. Wings a little longer than abdomen. Male claspers strongly curved, slender.

NATURAL ENEMIES

Although it would seem that the cap of the eggs is sufficiently exposed in most cases to permit of the introduction of parasite eggs, we have reared no egg-parasites nor have any other workers done so as far as we have been able to determine.

The exposed habit of the nymphs should render them an easy target for some of the smaller hymenopterous parasites but apparently this stage is also free from attack.

It is very interesting to note, however, that the larva of a gall midge (Cecidomyidae) has been recorded as attacking a lace-bug nymph in Portugal. This is referred to by H. F. Barnes in a paper entitled "Gall midges (Cecidomyidae) as enemies of the Tingidae, Psylidae, Aleyrodidae and Coccidae" in Bul. Ent. Res. **21** (3): 319, 1930. The brief reference in full is as follows:

Endopsylla endogena (Kieffer).
Kieffer, Zeits. f. Hymen. u. Dipt. 1, 1907, p. 129–130 (*Cecidomyia*); Genera Insectorum, fasc. 152, 1913, p. 222 (*Endopsylla*).

Male and pupa described. Kieffer bred a single male from a dead larva of *Stephanitis pyri F.* Pupation took place inside the Tingid and the adult emerged through a circular hole in the back of the host. The insects were sent by Tavares from Portugal. This species seems to be the most specialized gall midge

yet known being the only one known to live as an internal parasite and pupate inside its host.

We have found a small black and yellow spider on a considerable number of the leaves of the four trees of *Anona diversifolia* mentioned above as being badly infested with *C. gossypii* on the Insular Experiment Station grounds at Río Piedras. This spider has been determined by Prof. C. R. Crosby as *Theridula opulenta* Walckenaer, a cosmopolitan species and according to Petrunkevitch (Trans. Conn. Acad. Sci. **30**: 189–191, 1930) very common in Porto Rico. It spins a small web on the leaf and in several cases nymphs or adults of the lace-bug have been found caught within it. This spider however is probably not a very important factor in natural control.

A number of adults and nymphs, as well as of the brownish egg-masses of a Reduviid bug, *Zelus nugax* Stahl, have also been found on the leaves of the same trees. In several instances the nymphs have been observed feeding on those of the lace-bug. This Reduviid has been reported from several localities on the Island as having been found on various plants and trees but no observations have previously been made as to the insects upon which it is predaceous.

CONTROL

Corythucha gossypii has apparently never been sufficiently abundant on its various economic food-plants to make remedial measures seem worth while except in the case of lima beans.

When we first encountered the severe infestation on lima beans at Palo Seco, mentioned above, the grower told us that he had repeatedly sprayed with nicotine sulphate and soap at standard strengths but with poor success. He also mentioned that he had had equally poor results with the same combination in the control of the egg-plant lace bug, *Corythaica monacha* Stahl. A review of the literature dealing with definite experiments on the control of lace-bugs on various plants in various places disclosed the fact that nicotine sulphate was comparatively ineffective even when a small quantity of soap was added as a sticker and spreader. Crosby and Hadley, (Jour. Econ. Ent. 8: 409–414, 1915), although they did not use nicotine, state that the rhododendron lace-bug, *Stephanitis rhododendri* Horvath, (therein discussed under the name of *Leptobyrsa explanata* Heid.) was found to be readily controlled by the use of a soap solution, 1 pound in 10 gallons of water. Fink (U. S. D. A. Bul. 239, 1915) conducted a careful series of experiments in

the control of the egg-plant lace-bug, *Gargaphia solani* Heid. at Norfolk, Va., in which he carefully tested the comparative merits of soap alone and in combination with various strengths of nicotine sulfate. His results show "That the percentage of nymphs killed was but slightly affected by the increase in the amount of nicotine sulfate and the latter had no effect whatever on the adults; whereas with each increase in the amount of fish-oil soap there was a corresponding increase in the percentage of nymphs killed, until finally we arrive at a strength which will affect the adults. Above that strength we may then get perfect control of both the nymphs and adults." Fink found that eight pounds of fish oil soap in 100 gallons of water killed 100 per cent of the nymphs and 95 per cent of the adults. Wade (Okla. Agr. Exp. Sta. Bul. 116, 1917) experimenting with the control of the sycamore lace-bug, *Corythucha ciliata* Say, in Oklahoma obtained results similar to those reported by Fink and found that one pound of fish oil soap in 6 gallons of water gave the most satisfactory kill.

The writers have obtained 100 per cent kill of the nymphs and 95 per cent of the adults by using Octagon soap at the rate of one pound in eight gallons of water. In order to accurately measure the results the total number of nymphs and adults were counted on certain leaves on each plant and checks were left as usual. Care was taken to thoroly wet the underside of each leaf and to apply as nearly as possible a uniform amount of spray material to each plant.

It must be remembered that it is difficult to obtain quite so high a percentage of efficiency in commercial control on account of the difficulty of thoroly wetting the underside of all of the leaves where the insects are clustered. A fine driving mist under comparatively high pressure is essential and the application must be repeated as often as the increasing numbers of the bugs seem to make it necessary.

ACKNOWLEDGMENTS

The writers wish especially to express their thanks to Dr. Carl J. Drake, Head of the Department of Entomology, Iowa State College, for much assistance in supplying bibliographical and distribution data, the description of the adult insect and checking over the manuscript. Prof. C. R. Crosby of Cornell University has been good enough to send typewritten copies of several references needed. Mr. Harry G. Barber, Curator of Hemiptera, United States National

Museum was very helpful to the senior author while in the Museum in checking the identity of doubtful specimens in the collection.

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Explanation of Plates

Plate XL. Bean leaves showing characteristic yellowing and spotting due to lace bug feeding.

Plate XLI. Bean leaves showing progressive types of feeding injury starting from a healthy leaf (upper left) to a badly yellowed, spotted and dried leaf (lower right).

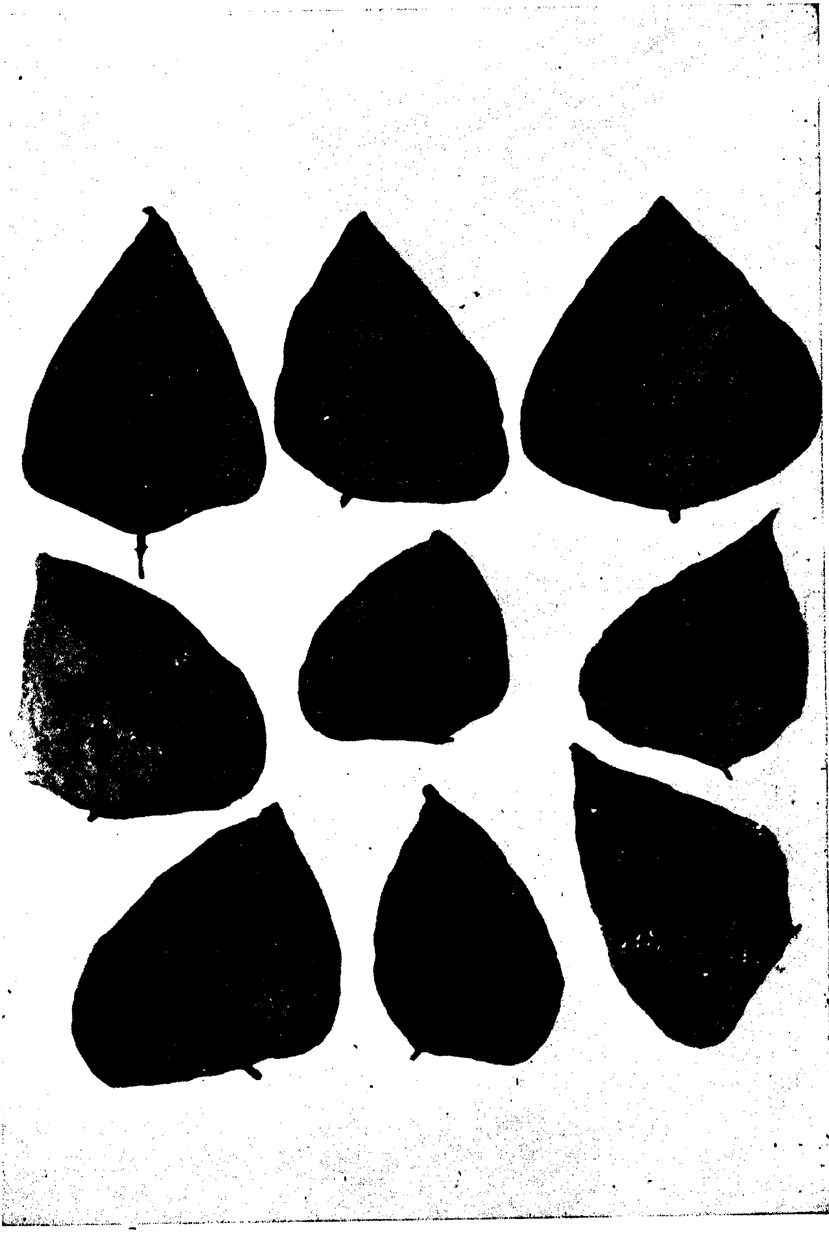
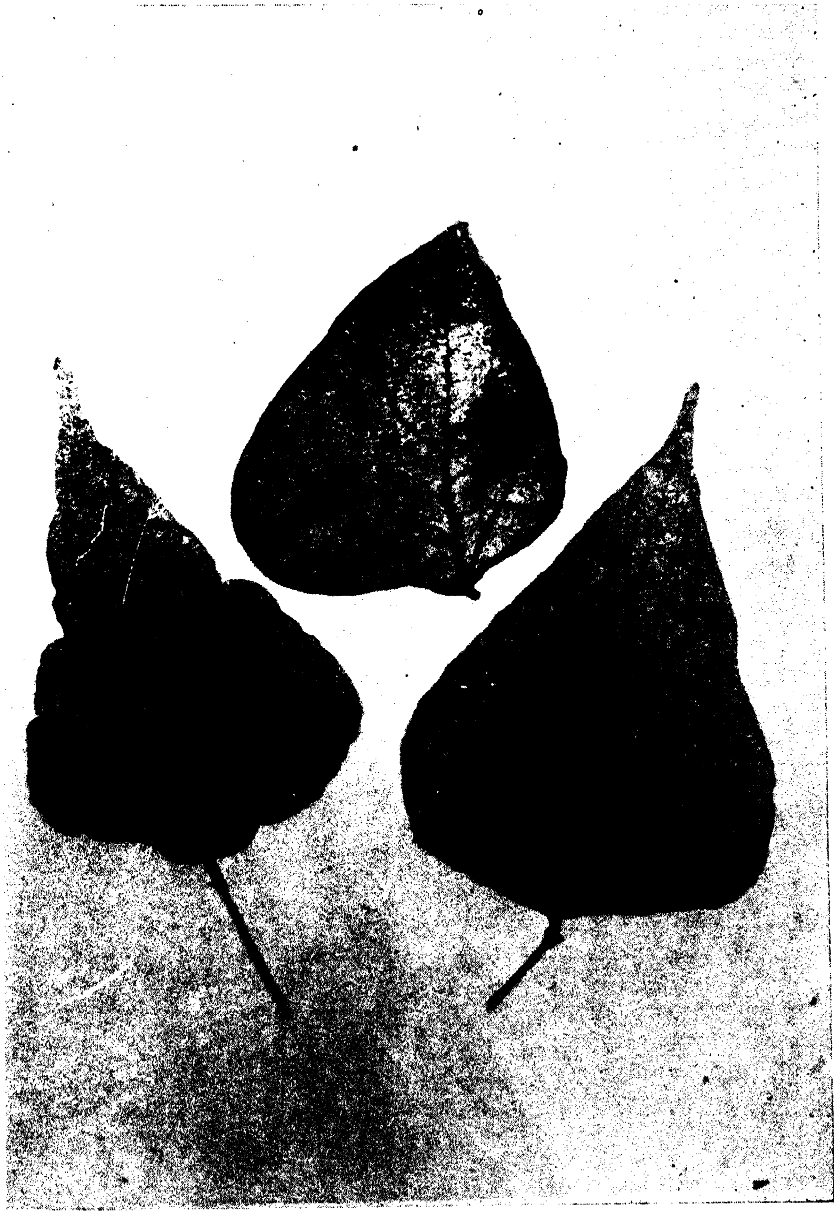


PLATE XLI.



THE HAITIAN COFFEE TREE CRICKET

By CHARLES H. ARNDT, formerly Director of the Coffee Station, and HERBERT L. DOZIER,* Entomologist, Service Technique, Port-au-Prince, Haiti

Haiti is very fortunate in that many serious coffee diseases and insect pests are not found in that country. This is somewhat offset, however, by the damage caused by a native tree cricket, recently described as *Chremon repentinus* Rehn.[1] This species in its sum total of features is probably nearest *Stenogryllus* Saussure, a genus also known only from Santo Domingo. It is related to some African forms and it was at first thought that the species might possibly have come to Haiti in early slave ships.

DISTRIBUTION

This cricket was not recognized as a serious pest until recent years when the damage it caused to young coffee plantations was observed. It is assumed that this insect is confined to the island of Hispaniola as it has not been reported to date from any other country where coffee insects have been seriously studied. It is widely distributed in Haiti and its work has been observed in the Massif de la Hotte, Rochelois Plateau, Massif de la Selle and the Massif du Nord, from sea level to an altitude of 4,000 feet.

ECONOMIC IMPORTANCE AND HOST PLANTS

It may possibly be a misnomer to call this insect "The coffee tree cricket" because it is indigenous to the island while coffee is an introduced plant. It has found coffee a very suitable plant for egg deposition and probably causes more damage to it than to any other plants of economic importance, thereby justifying the popular name assigned to it.

In the Fond-des-Negres valley this cricket lays numerous eggs in the stems of cotton but the damage does not seem to be serious on this host except in some instances where the stem becomes infected by parasitic fungi through the egg punctures. Other plants in which eggs are laid but on which the damage is of relatively little economic importance are Spanish cedar, *Cedrella odorata;* "Bois chene", *Catalpa longissima* (frequent); "Bois d'Orme", *Guazuma ulmifolia* (occasional); "Bois crapaud", *Psychotria*

[1] A New Genus of Eneopterinae from Hispaniola, Trans. Amer. Ent. Soc., 50: 87–92, 1930.

* Co-authors.

Brownei (frequent); castor oil, *Ricinus communis* (rare); mahogany, *Swietenia mahogani* (frequent); *Piper* spp. (occasional); *Russelia equisetiformis* (frequent); petioles of "Pistache des Indes", *Stercula apetela;* sour orange, avocado, saman, and cacao (rare). The terms in brackets indicate the relative frequency with which the egg punctures are found on the various plants as observed at the Fond-des-Negres coffee station. Native plants in which an abun-

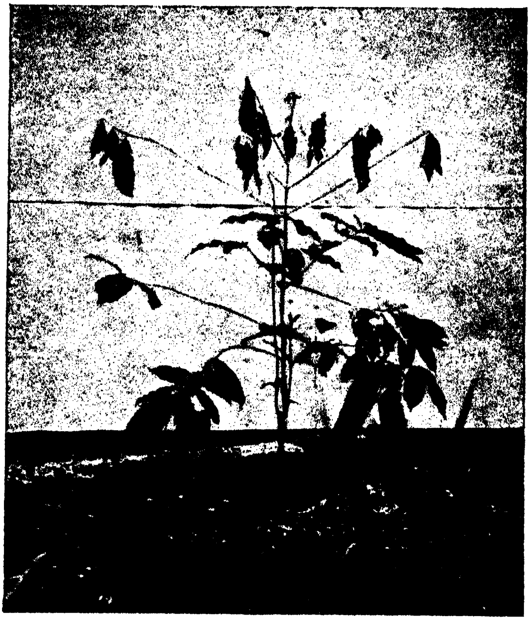


FIG. 1.—Wilting and Death of the Top of a Young Coffee Tree Following Egg Punctures by the Coffee Tree Cricket, and Subsequent Infection of the Stem by the *Fusarium* Fungus; Note Accessory Up-right Shoots Which Developed After the Injury.

dance of eggs can usually be found are "liane barrique", *Trichostigma octandra,* and two species of *Hamelia,* one of which is the common "bois corail" of the gardens, *Hamelia erecta.* Eggs have also been found in the stems of two native weeds, one belonging to the Menthaceae, the other to the Compositae. All plants of the latter two groups listed are mostly weeds which grow along water courses. Emphasis should therefore be placed on keeping all areas around the plantation free of these weeds.

NATURE OF INJURY

These crickets are very inconspicuous, hiding during the day beneath rubbish, old leaves, etc., and feeding at night. During the egg-laying period the females may be readily found at night by

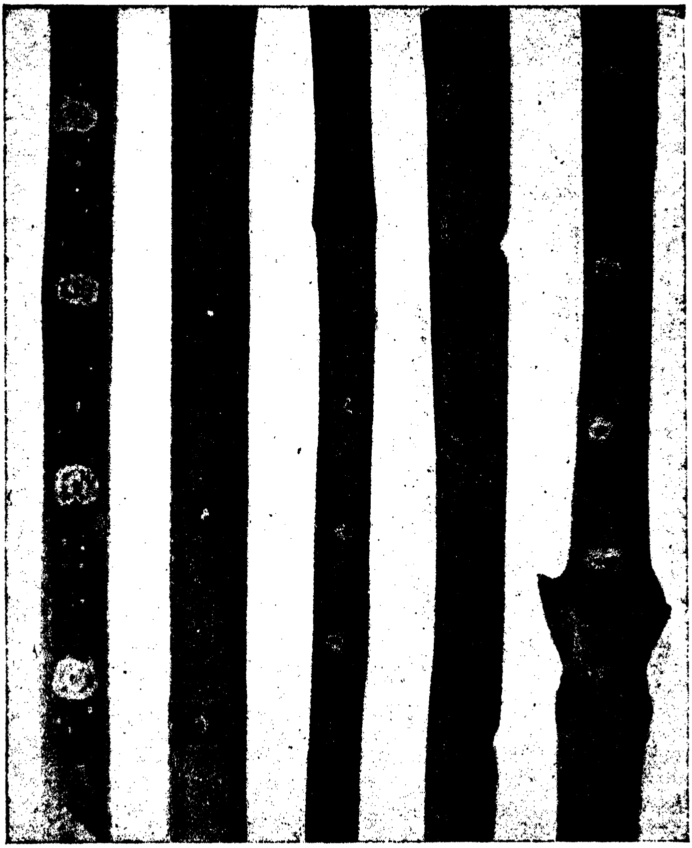


FIG. 2.—Stems of "Liane Barrique", ***Trichostigma octandra*****, Cotton and Coffee Showing Egg Punctures of** ***Chremon repentinus*** **Rehn, Natural Size.**

searching among the coffee trees with a flash-light. They are then easily captured while in the act of oviposition. The males are very rarely found and are much less abundant than the females.

One's attention is usually first attracted to the injury by this

insect by what appear to be holes in the recent growth of the upright stems. These "holes" are made by the removal of the bark from the wood over a somewhat rounded area of about 5 mm. in diameter (Fig. 2). In the center of this area will be seen a small hole which extends into the pith. This hole is made mostly by the ovipositor for the insertion of the eggs into the pith of the stem. From three to six yellowish eggs are laid lengthwise in the pith above and below the hole. Stems from 5–9 mm. in diameter which

FIG. 3.—Hypertrophy of Stem of Haitian Oak, *Catalpa longissima*, a Condition Which Frequently Occurs After Oviposition Punctures by *Chremon repentinus*, Reduced.

are still green, with the wood soft, and having a large amount of pith seem to be preferred. Holes are rarely made in stems in which the wood has become well hardened. For this reason few punctures are made on the laterals because their wood becomes hardened before they are of a sufficient diameter to interest the crickets for oviposition.

The removal of the bark by the cricket over a larger area than is necessary for the insertion of the ovipositor for egg-laying, seems

to be a habit adaptation to prevent the plant from closing the hole rapidly by a callus formation and thus smothering the developing eggs. The holes are, nevertheless, frequently closed by a callus when they are made on rapidly enlarging stems. This frequently occurs on the Haitian oak where very noticeable hypertrophies as large as 1×1.5 cm. may be formed (Fig. 3).

The egg punctures themselves would injure the coffee plants little if it were not for secondary effects. The first of these is the tendency of the punctures to weaken the stems mechanically so that they are likely to break later when the laterals above the punctures set a heavy crop of berries. This weakening effect would be much less and of relatively little importance if it were not for the frequent infection of the xylem through these holes by parasitic fungi. A species of Fusarium * (Fig. 4) is the organism most commonly attacking the wood through these punctures, causing a discoloration of the vascular cylinder, but occasionally *Cercospora coffeicola* is the infecting fungus.

The *Fusarium* first attacks the pith and then grows into the wood and bark. White masses of fruiting mycelium appear on the surface of the stem adjacent to the infected puncture. The bark and pith become dark in color and the cricket eggs are frequently destroyed. It is only rarely that an old cricket hole is found which is not infected by some fungus. Frequently the infection does not occur until after the eggs have hatched, or if infection has occurred earlier the growth of the mycelium will not be sufficient to destroy the eggs. When young stems are infected, the stem above the point of attack is frequently killed. The leaves of the top will suddenly wilt, then become brown, and later brownish-black before falling. In certain plots at the Coffee Station at Fond-des-Negres as many as 60 per cent of the tops of the coffee trees were killed by such infections which followed cricket punctures. The egg punctures are usually from 2 to 3 cm. apart although occasionally they may be placed closer and at times the punctures may be opposite each other. As many as fifty-two punctures have been counted on a 60 cm. length of a coffee stem. The largest number of punctures observed for a single stem was 218 in a 340 cm. portion of a *Trichostigma octandra* stem.

* Provisionally determined by Dr. C. D. Sherbakoff, as very similar to if not identical with *Fusarium martii* A. & W.

The most serious effect of the cricket injury to the stem lies in the effect of any injury to the upper portion of the coffee tree upon its configuration or shape. Such injuries to the upright stem remove

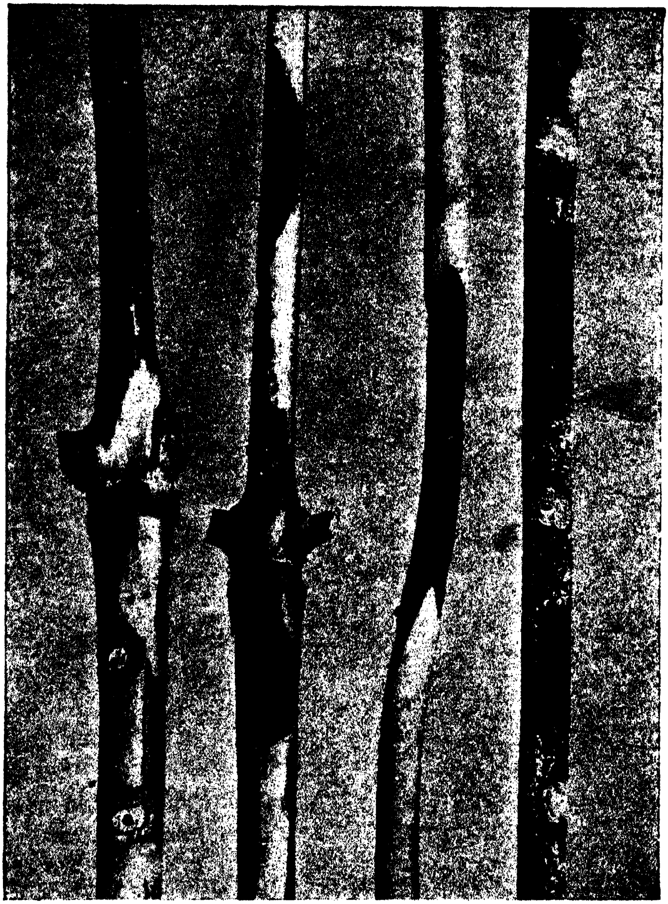


FIG. 4.—Coffee Stems Showing Various Degrees of Infection by *Fusarium* Disease, Following Egg Punctures, Natural Size.

the inhibition of the terminal bud on the normally dormant secondary buds. The removal of this inhibition results in the development of an entanglement of uprights and laterals which is very

difficult to control. When the trees are regularly damaged each year by injuries of this nature it is impossible to follow any particular system of pruning. The pruning will be difficult and will have to be directed toward the utilization of the less-injured and the uninjured shoots for the development of the fruiting branches. There is no question of the seriousness of the damage which may be caused by this cricket and unless some means is discovered to reduce its injury below that which has been observed at the Coffee Experiment Station, it will remain a serious handicap to commercial coffee growing on the Island. The older and less rapidly growing trees are less seriously injured because of the relatively lesser amount of stem in which eggs may be laid. Several observations indicate that this cricket causes more damage to coffee in sunny places than to plants located under shady conditions.

SEASONAL HISTORY

Egg-laying occurs most commonly after the rapid growth of the shoots begins in the spring, although it may occur at any time of the year when suitable young shoots are present. Eggs hatch from five to twelve months after deposition. All eggs of the same puncture hatch at about the same time, although eggs laid in the same stem but at different punctures may hatch at different times. Eggs which are laid in April, May, and June, will usually begin to hatch the following December. Most of them, however, will not hatch until several months later. The adults and nymphs are difficult to find but the very young ant-like nymphs may be found at almost any time of the year by searching carefully among the dense coffee foliage. They are most abundant from March to June.

The nymphs and adults seem to feed mostly at night and their food apparently consists mainly of scale insects, plant lice and other small insects. In our rearing cages they were constantly supplied with fresh *Saisettia hemispherica* and *Coccus viridis*, two scales commonly present on coffee foliage and stems. They appear to be distinctly cannibalistic when confined with each other in close quarters. One batch of nymphs hatched May 10th yielded a single male survivor which reached maturity August 10th, 1930. Other partial rearing records coupled with field observations show that the time from hatching to adult requires from eighty to ninety days.

DESCRIPTION OF STAGES

Egg (Fig. 5.)—Whitish in color, semi-translucent, elongate cylindrical. Without a distinct cap area differentiated, as is commonly found with many species of tree crickets. The head of the developing embryo is always oriented toward the opening. Average length 3.25 mm.; greatest width .788 mm.

FIG. 5.—Diagramatic longitudinal section of stem to show manner of oviposition.

Nymph.—First instar: Color reddish-brown, the abdomen darker; hind femora banded with white; basal third of antennae pale, remainder dark; cerci pale. Resembles a small ant. Length 3.5–5.2 mm.

Second instar: General color brownish-black, the base of abdomen and sides of thorax marked with yellowish-orange; a very narrow cross-band on abdomen pale; antennae black except pale base; cerci black. Length 5.2–8.3 mm.

Third instar: General color brownish-black, the thorax for the most part tawny, abdomen with narrow pale cross band; legs black except longitudinal pale markings and distinctly paler base of femora; antennae black, pale at base; cerci blackish at tips, lightening towards base. Length 8.3–11.4 mm.

Fourth instar: Color much lighter than in preceding stage; head except front part, thorax and legs, pale yellowish-testaceous, the thorax outlined with black borders, and the hind femora with several longitudinal black markings; antennae black, banded with yellow at base and about the middle; cerci pale, black at tip. Length 11.4–15.5 mm.

Fifth instar: Distinctly paler, the head pale except the eyes and front part, dark; thorax outlined with narrow black border; abdomen for the most part dark, central median portion of each segment pale; wing pads pale, the venation and outer sides somewhat darker; legs pale, with lineate longitudinal dark streaking on femora. Antennae yellow except a very narrow black band a short distance from the base; cerci pale; ovipositor pale. Length 15.5–22. mm.

Adult (Fig. 6)—General color of head, pronotum and legs pale ochraceous-orange; abdomen brown with pale ochraceous-orange evident on dorsal surface; fore part of head and eyes fuscous-

brown; antennae pale yellowish-orange; pronotum with the entire border margined with brownish-black; tegmina or wing covers a pale clay color, the veins dull yellow. Legs pale, ventral margins of the femora and dorsal surface of the middle and hind femora lineate with fuscous-brown. Ovipositor brownish-black. The sexes may be at once distinguished by the difference in shape and vena-

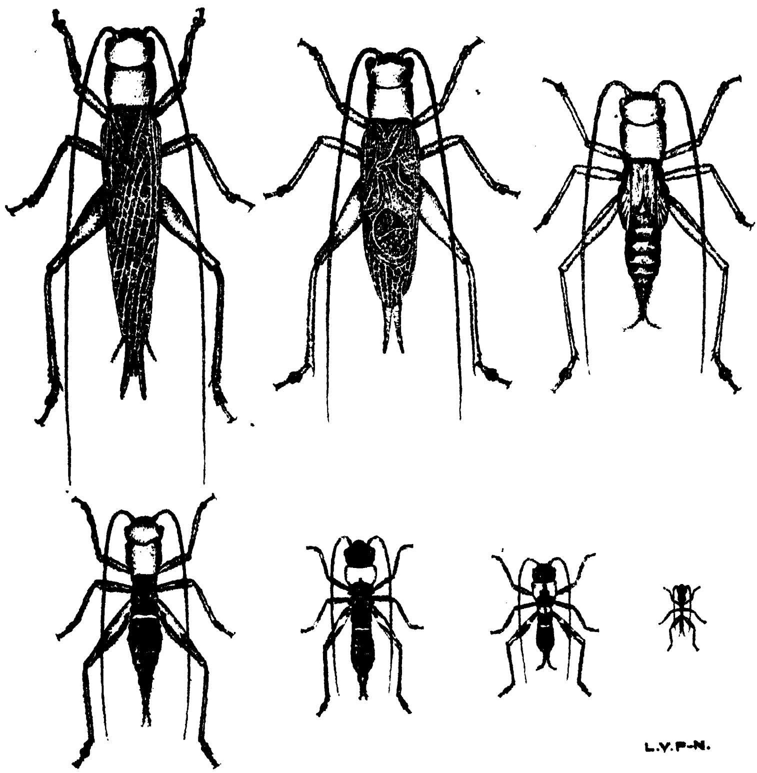


FIG. 6.—Adult Female and Male and Stages of Development of the Coffee Tree Cricket, Enlarged One-third.

tion of the tegmina. In the female the tegmina are very elongate, distinctly longer and more slender than with the male, the apices surpassing the tips of the tegmina. In the male the tegmina are broader with very different venation and with a sub-ovate tympanum. Length of male, 18.9–22. mm.; length of female, including ovipositor, 26 mm.

NATURAL ENEMIES

A very small ant has been observed to enter through the punctures, enlarge the holes, burrow though the pith from puncture to puncture, destroying the cricket eggs.

The *Fusarium* disease often infects and destroys the eggs through its mycelium.

In actively growing stems the holes are often closed by calluses and the eggs smothered.

The most important natural enemy of the coffee tree cricket, however, is a very small, elongated scelionid wasp which has only recently been described. As this original description was published in French a full translation of same is given here to enable recognition:

Leptoteleia arndti Dozier

Bul. No. 26, "Le Criquet Haïtien du Caféier". Service Technique, Port-au-Prince, Haiti, page 15.

This species is placed in Kieffer's genus *Leptoteleia* of which *Baryconus oecanthi* Ashmead is the genotype and is undoubtedly congeneric with the type species which is parasitic in the eggs of the snowy tree cricket, *Oecanthus niveus*, of the United States. *Leptoteleia oecanthi* differs from this new species in having a shorter ovipositor, black legs, a black scape and entirely black head, thorax, and abdomen.

General form and abdomen extremely elongate. Head and antennae black except the scape which is yellowish; thorax yellowish-orange except the meso and metathorax which is darker on dorsum; first abdominal segment dark but the others are yellow, each segment divided by orange annulation; legs orange-yellow except distal knees and tarsi of the middle pair, the tarsi of the hind pair with exception of the proximal third of first segment, and the distal third of tibiae of second and third pair of legs, which are fuscous.

Length, excluding ovipositor, 3.05 mm.; length of ovipositor, moderately exserted, .47 mm.; greatest width across humerals .458 mm.

Described from a large series that issued March 23–24, 1930 from eggs of *Chremon repentinus* Rehn, collected at Fond-des-Negres, Haiti, on February 19th. These eggs were laid during the previous summer (April–June) and no parasites issued from fresh eggs deposited during the two months previous, suggesting only a single generation each year.

Type female mounted in balsam on slide, deposited (U.S.N.M. type number 43,328) together with series of point-mounted and alcoholic specimens in the U. S. National Museum.

These scelionid parasites have been observed to hatch from February to June. The head of the developing cricket host is always oriented toward the opening while that of the egg parasite is always away from the opening.

CONTROL MEASURES

When a large continuous area is planted to coffee and this area can be kept free of other host plants which might serve as egg depositories, it may be possible to greatly reduce the injury and prevent further increase of the crickets by removing all of the stems in which eggs have been laid between the time of egg-lying and hatching. In many sections this would necessitate pruning before the completion of the coffee harvest and earlier than would be otherwise desirable. It would also involve a considerable sacrifice of the coffee crop of the succeeding year as many of the infested shoots will have produced laterals on which floral buds are maturing. The loss from this source, however, might be much less than that which would be produced if the crickets were allowed to multiply unhindered.

These prunings should not be burned immediately but should be collected and placed in a specially screened room so that the issuing egg parasites would be allowed to escape and carry on their benefical work.

It is hoped that some suitable, cheap, and safe material will be found that can be used to kill or smother the eggs in the stems. Substances that may injure or burn delicate plant tissues must be avoided. Experiments are planned using a pine tar oil product that has great penetrating properties and yet is non-injurious to the plant. This can be easily applied with a few strokes of a paint brush in the hands of unskilled laborers.

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of PUERTO RICO

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SUPPLEMENTARY REPORT ON THE HETEROCERA OR MOTHS OF PORTO RICO
By *Wm. T. M. Forbes.*

THE INFESTATION OF YOUNG OKRA PODS BY PINK BOLLWORM IN PORTO RICO
By *George N. Wolcott.*

A NEW SPECIES OF ARISTELLIGER FROM NAVASSA
By *Chapman Grant.*

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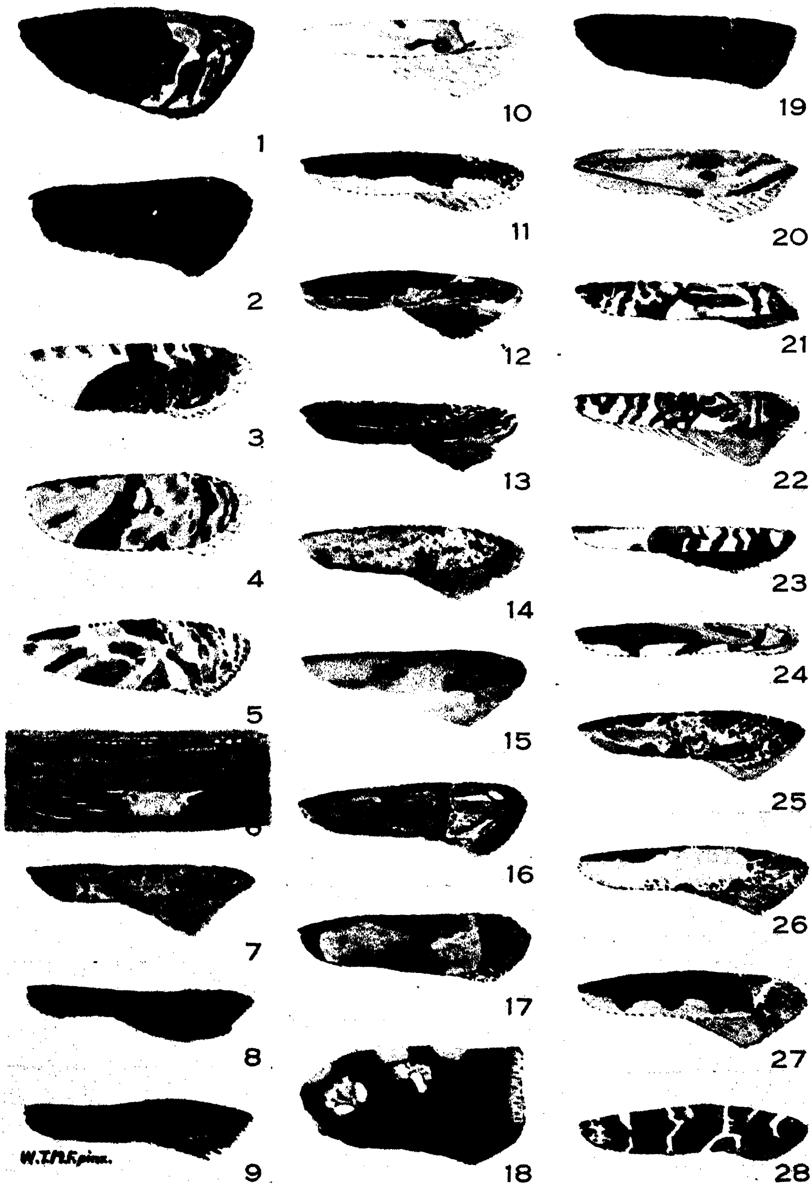
Explanation of Plate XLII

Fig. 1. Gymnandrosoma trachycerus
Fig. 2. Oletheutes anthracana
Fig. 3. Saphenista bunteoides
Fig. 4. Saphenista lepidulana
Fig. 5. Saphenista semistrigata
Fig. 6. Cosmopteryx antillia
Fig. 7. Prochola fuscula
Fig. 8. Stilbosis phaeoptera
Fig. 9. Perimede purpurescens
Fig. 10. Aphanosara planistes
Fig. 11. Tholerostola evippella
Fig. 12. Aristotelia vagabundella
Fig. 13. Aristotelia diolcella
Fig. 14. Aristotelia lignicolora
Fig. 15. Glaucacna iridea
Fig. 16. Anacampsis meibomiella
Fig. 17. Anacampsis melanophaea
Fig. 18. Hypercallia rosacea (Haiti)
Fig. 19. Trichotaphe elliptica
Fig. 20. Triclonella rhabdophora
Figs. 21, 22. Acrocercops zebrulella male, female
Fig. 23. Acrocercops cymella
Fig. 24. Acrocercops pontifica
Fig. 25. Mea yunquella
Fig. 26. Mea incudella
Fig. 27. Protodarcia bicolorella
Fig. 28. Protodarcia argyrophaea

PLATE XLII



NEW MOTHS FROM PORTO RICO

The Journal of the Department of Agriculture

OF PORTO RICO

Published Quarterly: January, April, July and October of each year

MELVILLE T. COOK, EDITOR

VOL. XV OCTOBER 1931 No. 4.

SUPPLEMENTARY REPORT ON THE HETEROCERA OR MOTHS OF PORTO RICO

By WM. T. M. FORBES, Cornell University, Ithaca, New York.

This report is an appendix to the revision of certain families of moths in the Scientific Survey of Porto Rico, vol. xii, no. 1, 1930, and includes the same families. It is based primarily on material in those families collected by the writer in the spring of 1930, and represents that material as fully as it has been worked up. I have also included a considerable number of records based on specimens collected by Leonard, Hoffman, Seín and Mills since my return, and sent up to me. Such material is duly credited in the text. The year-date is 1930 except as stated.

For convenience of reference I have made this paper uniform in style with the former report, and have put against each species the page-reference to the former paper. In the cases of additional species regular headings are used, and a key-bibliography.

The corresponding material in the Butterflies, Noctuidae, Geometridae and Pyralididae is being studied by Dr. Schaus and Mr. Watson, and will be incorporated in their reports on those families. A considerable number of other insects were taken more or less incidentally. A few of these have already been reported on by Dr. Curran, and the remainder, we hope, will be included in reports on the various groups of insects as they come out.

The material on which this report is based, including the holotypes, is in the Museum of the Department of Entomology of Cornell University. A second set, so far as possible, will be put in the U. S. National Museum. I have included a few records for Haiti from specimens collected by Mr. O. Fulda about the same time. These specimens are also in the Cornell collection. While the Haiti fauna is richer than that of Porto Rico and doubtless includes many things absent from the smaller island, part of these species will surely be found eventually in Porto Rico. We can now say that our knowledge of the Porto Rico Macrolepidoptera is well advanced, but in the micros, the large percentage of new species taken (some 50 in

all, not all in condition to describe) and of new records for the island, show that at least half of the island fauna is yet to be discovered. In the boring and leaf-mining genera, such as the Gracilariidae, Nepticula, and Phaloniidae, no doubt an even larger proportion is still unknown. There is need for much work in this field, and especially for rearing and life-history work.

I am much indebted to numerous people who have helped me in many ways in this survey, and especially to the Hon. C. E. Chardon, then Commissioner of Agriculture, to Dr. N. L. Britton and Mr. Wm. P. Kramer, then Chief Insular Forester, for personally conducting me to many entomologically rich spots on the island, and to Drs. M. D. Leonard and W. A. Hoffman, and Messrs. Francisco Seín, Jr., and A. S. Mills, for similar help and also for a great amount of material collected, not only while I was with them, but since. In working up the material I have had especial help from the Lepidopterists at the U. S. National Museum, and especially Mr. August Busck, but he is not responsible for the conclusions I have come to, and no doubt will disagree with several of them.

In the following pages the species are taken up in the order in which they appear in the former report.

LIST OF NEW SPECIES DESCRIBED IN THIS PAPER

EUCHROMIIDÆ

Phoenicoprocta parthenii Fabricius (p. 20). Coamo Springs, April 24, 1930.

Nyridela chalciope Hübner (p. 22). Lares, December (Seín).

Cosmosoma auge Linnaeus (p. 23). Coamo Springs, Apr. 5–9; El Yunque, Mar. 29, Apr. 23. Lares, Sept. (Seín).

C. achemon tyrrhena Hübner (p. 23). All four specimens have the ground of the fore wing mainly orange; the males have the usual orange patch opposite the lower angle of the cell, and even in the female the base of cell Cu_1 is filled with orange; the form therefore, so far as Porto Rico is concerned, is a good race, and such specimens appear never to be taken on the mainland; but in Jamaica both forms are found. *C. bifcnestratum* Dyar is a synonym of *tyrrhene*. Coamo Springs, Apr. 10, San Germán, Apr. 16, Cataño, Nov. (Rachel Dexter), Lares, Sept. (Seín).

Lymire flavicollis Dewitz (p. 24). Coamo Springs, Apr. 10, El Yunque, Apr. 22.

Horama panthalon Fabricius (p. 25). This species varies considerably and in part locally, and I believe the names *stoneri* Lindsey, and *serena* Schaus are no more than minor races. My specimens from San Germán, Apr. 16, 17, agree substantially with *stoneri* Lindsey, having a nearly solidly orange hind wing; specimens in the Experiment Station collection from Boquerón (labelled San Germán) are of a distinctly smaller and darker strain, while one from Petionville, Haiti (Fulda) is largely brown-black, and most nearly represents the type.

Correbidia terminalis Welker (p. 27). The race-name *continentalis* can hardly be held, as the Lares specimen reported below is darker even than normal continental specimens, and has a deep orange-red ground; the National Museum has similar specimens from Baracoa, Cuba. El Yunque, Mar. 29, Lares, Sept. 29 (Seín).

NOLIDÆ

Nola bistriga Möschler (p. 29).

Curiously enough all the known specimens of this and the following species (19 besides the two types of *bistriga*) are females. The markings of all my specimens are black and Hampson's figure of a type also suggests black markings, but the original description calls them brown. El Yunque, Mar. 29, Apr. 22, 23.

N. sinuata Forbes (p. 29). This species has close relatives in South America, especially an undescribed one which I took in Brit-

ish Guiana, but it appears to be distinct. Coamo Springs, Apr. 6–10. Cornell Univ., type No. 1031.

Arctiidæ

Progona pallida Möschler. The black costal edge, used by Hampson to separate this species from *P. sadima* Schaus, of Brazil, is present in both, but the latter is a much larger and paler species, with the hind wing rather paler than the fore wing. *P. ignota* Schs. is correspondingly darker. The type of *pallida* was no doubt faded, as my fresh specimens are gray, while older ones become light brown. The species seems common in Porto Rico. San Germán, Apr. 16, 17, El Yunque, Mar. 28, Apr. 22, 23, Dorado, May 30 (Hoffman), Lares, July 28 (Leonard), Dec. (Seín).

Mulona nigripuncta Hampson (p. 33). San Germán, Apr. 17, Palmas Abajo, June 23 (Hoffman), Lares, July 28 (Leonard).

Afrida charientisma Dyar (p. 34). The two specimens presumably represent the species reported doubtfully by Möschler as *A. tortriciformis* on the basis of a poor specimen; the latter can be recognized by its modified male hind wings. El Yunque, Apr. 22.

Eupseudosoma involutum Seppe (p. 34). Lares, Dec. (Seín).

[**Robinsonia** Grote

Similar to *Eupseudosoma*, but fore wing with M_3 arising well before end of cell, hind wing with R and M_1, M_{2+3} and Cu_1 stalked. Markings normally, as in the following species, of brown bands on a white ground.

Robinsonia formula Grote

1865. *Robinsonia formula* Grote, Proc. Ent. Eoc. Phil., v, p. 241, pl. iv, fig. 3.
1901. *Robinsonia formula* Hampson, Cat. Lep. Phal. iii, p. 13.
1919. *Robinsonia formula* Strand, Lep. Cat. xxii, p. 3.
1921. *Robinsonia formula* Seitz, Macrolep. World v, p. 343.
(not *R. formula* Druce, Biol. Cent.-Am. Lep. Het. i, p. 117).

Fore wing less than 2½ times as long as wide. White, fore wing with brown borders, and a diagonal stripe across it.

Cuba. Haiti; Petionville, May–June (Fulda).]

Ammalo insulata Walker (p. 35). Cataño, Apr. 21. Haiti: Petionville, May–June, common (Fulda).

Phegoptera bimaculata (p. 36). I have lately received this spe-

cies from Jamaica, which confirms the probability of the Porto Rico record; previously I had not seen the species from the West Indies.

Microdota Dognin

Ocellus well developed; male antenna broadly pectinate, but short and weak (in the P. R. species); palpus moderate, oblique; hind tibia with end-spurs only. Fore wing with normal venation, without accessory cell; R_2 typically free, in the P. R. species shortly stalked; hind wing with R and M_1 stalked, M_2, M_3 and Cu_1 well separated at origin. Scaling very thin, with wings translucent.

The present species looks almost exactly like the type, *M. lenistriata* Dognin, but has much weaker antennae and stalked R_2. The pattern is pactically identical. It will key to Halysidota, but it is very much smaller and weaker, looking like a Lithosiid or Psychid.

Microdota hemiceras new species

Male antenna much shorter than in *M. lenistriata* but with about the same number of segments (30), hardly more than 1/3 length of fore wing, the pectinations shorter and weaker. Clay color dusted with fuscous, the lighter color on the fore wing showing as innumerable semiconfluent rounded dots on the fuscous ground, on the hind wing covering most of the surface; the antenna with a few irregularly scattered fuscous segments on shaft only; head and dorsum similar, but less distinctly flecked, also fore legs and middle and hind tibiae and tarsi, the remainder of under side of body and legs of the clay color only. Fore wing with a blackish shade along lower discocellular vein, faintly extended along Cu to origin of Cu_2. Expanse 16mm. (type) to 25mm. (paratype).

Porto Rico: San Germán, Apr. 16 (type) and Coamo Springs, Apr. 4 (paratype). Cornell University, type no. 1081.

Halysidota cinctipes Grote (p. 36). Lares, Dec. (Seín); a curious dark and suffused form, possibly representing a new subspecies.

Calidota strigosa Walker (p. 37). Coamo Springs, Apr. 9.

Ecpantheria icasia icasia Cramer (p. 37). San Germán, Apr. 16, El Yunque, April. 23, Jájome Alto, June 18 (Hoffman), Lares, July 28 (Leonard).

Utetheisa ornatrix Linnaeus (pp. 38–40). Two races of this species overlap in Porto Rico, but any one colony appears normally to be almost wholly of one them, with a few intermediates and odd specimens of the other. The colonies examined were distributed as follows:

Dominantly *U. o. ornatrix*

Hatillo; Aguacate (Aguadilla); Puerto Real and Salinas (Leonard), Vieques Id. The Vieques Island colony had several red

specimens with the reduced black spotting of typical *ornatrix*, a particularly striking form.

Dominantly *U. o. stretchii* Buttler

Isabela, Río Piedras, Pueblo Viejo, Coamo Springs, San Germán. A few of the Río Piedras females had red-tinted hind wings and might be considered transitional to the *venusta* and *bella* forms which occur farther west.

[*U. o. venusta* Dalman

Freres, Haiti (Fulda). The usual Cuban form.]

PERICOPIDÆ

Hyalurga vinosa Drury (p. 42). Río Piedras, Apr. 4, Coamo Springs, Apr. 4, 5.

AGARISTIDÆ

Tuerta sabulosa Boisduval (p. 43). San Germán, April 16.

NOTODONTIDÆ

Rifargia haitia Schaus. Petionville, Haiti, June 13 (Fulda).]

SPHINGIDÆ

Herse cingulata Fabricius (p. 50). Puerto Real, Vieques Id., Ap. 28, 29; July 9 (Leonard).

Cocytius antaeus antaeus Drury (p. 52). Hato Rey, Mar. 31 (Fernando Chardon).

Phlegethontius sextus jamaicensis Butler (p. 53). Puerto Real, Vieques Id., Apr. 28.

[*P. brontes cubensis* Grote. Haiti: Petionville, June 26 (Fulda).]

P. brontes smythi Clark (p. 54). Coamo Springs, Apr. 7, 10; San Germán, Apr. 17.

Protambulyx strigilis Linnaeus (p. 54). Coamo Springs, Apr. 7.

Erinnys ello Linnaeus (p. 58). Coamo Springs, Apr. 6, Puerto Real, Vieques Id., July 8 (Leonard); Haiti: Petionville, June 1 (Fulda).

E. obscura obscura Fabricius (p. 59). Puerto Real, Vieques Id., July 9 (Leonard). Haiti: Petionville, June (Fulda).

[*E. guttularis* Walker. Petionville, Haiti, June 1 (Fulda).]

Pachylia ficus Linnaeus (p. 60). Hato Rey, Mar. 31 (Fernando Chardon), Puerto Real, Vieques Id., Apr. 28, 29.

Epistor lugubris Linnaeus (p. 61). Lares, Dec. (Seín).

Xylophanes tersa Linnaeus (p. 68). Coamo Springs, Apr. 5, 7, Cataño, Apr. 21, Puerto Real, Vieques Id., Apr. 28, 29; July 9, (Leonard).

X. pluto Fabricius (p. 69). Coamo Springs, Apr. 6.

Celerio lineata lineata Fabricius (p. 69). Coamo Springs, Apr. 6–10, Cataño Apr. 21, Aguirre, Apr. 15.

EPIPLEMIDÆ

Nedusia excavata Möschler (p. 71). Jájome Alto, June 18 (Hoffman). Haiti: Petionville, May–June (Fulda).

Epiplema ineptaria Möschler (p. 72). Coamo Springs, Apr. 9–10, San Germán, Apr. 17, Dorado, June 13 (Hoffman). This species shows a well-marked sexual dimorphism; the male is grayer, especially on the fore wing, and the hind wing is rounder and appears to have lost vein Cu_2.

HYBLÆIDÆ

Hyblæa puera Fabricius (p. 73). Lares, Sept. 29 (Seín).

THYRIDÆ

[*Rhodoneura myrsusalis* var. *immaculalis* Möschler (p. 74). Haiti: Petionville, June 13 (Fulda).]

PTEROPHORIDÆ

Adaina bipunctata Möschler (p. 75). Coamo Springs, Apr. 4–10; El Yunque, Apr. 23, Santurce, Mar. 23 (Hoffman), Dorado, May 30 (Hoffman); Aguirre, Apr. 2–3, 1931 (Leonard and Mills); Puerto Real, Vieques Id., Apr. 29.

A. participata Möschler (p. 76). Coamo Springs, Apr. 9, Puerto Real, Vieques Id., Apr. 28; Lares Sept. 20 (Seín).

P. basalis Möschler (?) (p. 77). Lares, Sept. 20 (Seín); a very poor specimen, but much too large for any other species known to the region.

P. inquinatus Zeller (p. 77). Coamo Springs, Apr. 4.

Marasmarcha pumilio Zeller (p. 78). San Germán, Apr. 17. Larva on Meibomia in Cuba (Busck—N. M.). Several other specimens are much paler than *pumilio* as determined by Barnes and Lindsey and have fewer black scales in the fringes. They resemble Meyrick's figure of *liophanes*, treated by Barnes and Lindsey as a synonym of *pumilio*. Coamo Springs, Apr. 5, Cataño, Apr. 21, Puerto Real, Vieques Id., Apr. 28–29.

Trichoptilus defectalis Walker (p. 78). Coamo Springs, Apr.

4–10, Aguirre, May 22 (Leonard), Apr. 2–3, 1931 (Leonard and Mills); Puerto Real, Vieques Id., Apr. 28–29.

Platyptilia pusillidactyla Walker (p. 80). Coamo Springs, Apr. 4–10.

Platyptilia crenulata Barnes and McDunnough

1913. *Platyptilia crenulata* Barnes and McDunnough, Contr. Nat. Hist. Lep. ii, p. 185, pl. iii, fig. 8.

1921. *Platyptilia crenulata* Barnes and Lindsey, Contr. Nat. Hist. Lep. iv, p. 316, pl. xli, fig. 15, pl. l, fig. 5.

Reddish brown, with white subterminal line across both lobes of fore wing, a triangular blackish shade before subterminal line in the first lobe, and another before the notch. Base and cell also with dark and whitish scaling. Third feather of hind wing with a triangular scale-tuft *near the apex* and numerous large black spatulate scales for most of its length. Abdomen with middorsal black spots defined with white on posterior segments. 13 mm.

Florida, Arizona, South California. P. R.: Coamo Springs, Apr. 4. The specimen is rubbed but agrees in essential characters with a cotype of this species.

ORNEODIDÆ

Orneodes eudactyla Felder (p. 80). Coamo Springs, Apr. 4, 10.

TORTRICIDÆ

Subfamily TORTRICINAE

Archips species (p. 83). The specimen in the Experiment Station collection is imperfectly expanded, but agrees with *A. jamaicana* so far as can be made out.

Paratorna rotundipennis Walsingham (p. 83). Fore wing with dark stripes from middle of costa to lower angle of cell, and across apex. Cu_2 and 2d A closely crowded at anal angle, 1st A anastomosing with 2d A. Expanse 10 mm. Boquerón ("San Germán") in Experiment Station collection.

Coelostathma parallelana Walsingham (p. 84). El Yunque, Mar. 30; Lares, Sept. (Seín). Too poor for certainty but no doubt this species.

Drachmobola insignitana Möschler (p. 84). Three females are considerably darker than implied by Möschler's description, but fit well enough. The male is strikingly different. Antenna strongly fasciculate-ciliate. Fore wing creamy, the mixed light buff and blackish reticulation conspicuous only on outer half of wing and

middle of inner margin; a diffuse dark antemedial spot on inner margin and some dark discal striæ opposite it, two contrasting blackish patches on costa, the first at two-fifths, the other half way between it and apex, both rounded, but with the basal side obliquely cut off, corresponding to the two oblique bands of the female. Some black costal points at tips of veins outwardly. Hind wing conspicuously reticulate with fuscous. In two of my females the two costal spots are traceable, in the other all markings are obsolescent.

El Yunque, Mar. 29 (male), Apr. 22, 23 (female); Jájome Alto, June 18 (Hoffman).

Sparganothis flavedana Clemens (p. 85). Antillean specimens are consistently very largely tawny, and represent a good race at least. Lares, Dec. (Seín).

Sparganothis saturatana Walker

1863. *Teras saturatana* Walker, List. Lep. Ins. B. M. xxviii, p. 294.
1912. *Sparganothis saturatana* Meyrick, Lep. Cat. x, p. 57.
1913. *Sparganothis saturatana* Meyrick, Gen. Ins. cxliv, p. 58.

Fore wing fawn, with brown reticulation and transverse lines toward outer margin. Hind wing orange. 18 mm.

This species differs from *S. effoctana* by the orange hind wing, from *S. flavedana* by the smooth fore wing and much larger size. The Porto Rico specimen agrees with a Panama specimen in the National Museum, collected by Busck and determined by Walsingham, but not so well with the original description and a figure in the National Museum of Walker's type.

Honduras, Panama. P. R.: Coamo Springs, Apr. 6.

Subfamily Olethreutinae

Olethreutes albimaculana Walsingham (p. 86) should read *albimacula*. The following reference should be added:

1914. ***Olethreutes albimacula*** Walsingham-Durrant, Biol. Cent.-Am. Lep. Het. iv, p. 251. (Central and South America).

O. canofascia Forbes (p. 86). Santurce, Mar. 25 (Hoffman).

O. hebesana Walker (p. 88), Coamo Springs, Apr. 4, 7; Puerto Real, Vieques Id., Apr. 29.

Olethreutes anthracana new species (Pl. XLII fig. 2)

The following species is not a true Olethreutes but will go with several South American species in a new genus. It has most of the characters of Olethreutes, except for some very aberrant features, but has the tufted hind tibiae of Phaecasiophora.

Head close-scaled, with a vertical depressed line in front. Palpi close-scaled, the third segment wider than long, inconspicuous; antennae shortly pubescent, simple; coxae and femora with masses of large spatulate scales, the middle and hind tibiae shaggy with masses of longer spatulate scales; no pencil seen on hind tibia. Thorax with thicker scaling behind but no real tuft; abdomen with narrow hair-like scales, and a dense terminal tuft, borne on the somewhat modified eighth segment, shaggy. Fore wing with accessory cell large, normal; R_3–R_5 approximate at base, R_2 widely separated, Cu_2 anastomosing with 1st A. Hind wing with R and M_1 merely approximate, Cu_2 from middle of lower side of cell but free from 1st A; anal region roughly scaled but not modified. Male genitalia heavily spined, of Olethreutes type (pl. XLV fig. 21); with cucullus rounded over and reduced, the sacculus also short, and most of the length taken up by the portion bearing the spine-clusters; cluster 1 very long, running along the ventral edge of the valve, with numerous heavy spines, cluster 2 a small group of weak spines hardly set off from its basal end; uncus flat and spatulate with a tuft of long hair; socii short hairy lobes, but a pair of large tufted membranous lobes at articulation of valves; penis unarmed (apparently, there might be deciduous spines). Eighth segment heavily chitinized, with a pair of shallow pockets bearing enormous tufts of several types of spatulate black hair-scales.

Head and thorax with palpi and scaling of antennae blackish; abdomen fuscous, anal tuft blackish. Fore wing marked with innumerable semiconfluent lighter spots on a blackish ground, the spots giving the general wing color, which is wood brown with crimson iridescense toward the base (exaggerated in the figure) and is coal black outwardly. Base solid blackish, extending out to a deeper black spot at basal angle; a solid black medial triangle below the cell, with one of its sides resting on the cell, and apex on inner margin; and a blackish shade extending up from end of cell. A contrasting yellow discal dot. Dark ground gathering to form a vague dark subterminal shade, parallel to outer margin; terminal line darker; fringe concolorous, faintly striped. Costa with a series of black spots, the four on outer two-fifths, larger. Hind wing light fuscous, the scales on the under side raised, but not so translucent as *Gymnandrosoma trachycerus*. 23 mm.

El Yunque, Luquillo National Forest, P. R., 1500–2000 ft. Apr. 23 at light. Holotype male, Cornell Univ., type No. 1035.

Gymnandrosoma Dyar

Palpi moderate, roughly scaled; thorax with a posterior tuft. Fore wing with most of the characters of Olethreutes, hind wing typically with M_2 and $_3$ parallel and well separated, but with M_2 strongly curved and approximated to M_3 at base in the Porto Rico species (*aurantianum* group). Male typically with strong sexual modifications of abdomen, wings and hind legs, not described in *desotanum*.

The two Porto Rico species belong to an aberrant group typified by the Brazilian *G. aurantianum*. They will run to Olethreutes in

the keys, though the male genitalic characters show their kinship to the other Gymnandrosomas. They may be distinguished from *O. hebesana* by the larger size and absence of lead gray areas on the fore wing.

Gymnandrosoma desotanum Heinrich

1926. *Gymnandrosoma desotanum* Heinrich, U. S. Nat. Mus. Bull. cxxxii, p. 72; pl. xxi, fig. 123 (female genitalia).

1931. *Gymnandrosoma desotanum* Heinrich, U. S. Nat. Mus. Proc. lxxix, art. 13, p. 6; pl. v, fig. 18 (male genitalia).

Surface mainly light wood-brown, in the form of double striations on a smoky brown ground, which appears solidly in a large median area, narrow at costa but much widened at middle of wing; and a rounded area before middle of outer margin, which tends to extend out toward costa. A white dot at end of cell. One pale stria at middle of outer margin more conspicuous than the rest, but short, followed by a bar of the dark ground. Terminal line barred wood brown and blackish. Hind wings and frings fuscous. Palpi "blackish fuscous slightly dusted with ochreous; upper edge sordid whitish".

Everglades, Florida (U. S. A). Porto Rico: Puerto Real, Vieques, Id., Apr. 28. Heinrich has verified my determination and has compared the female genitalia with the type, finding no significant difference. Larva in red mangrove seed (Heinrich).

Gymnandrosoma trachycerus new species (pl. XLII fig. 1)

Male antenna densely ciliate-fasciculate, slightly thickened at base, but not notched. Hind tibia without pencil, abdomen without basal tufts. Fore wing with R_1 and $_2$ approximate at origin, parallel to near margin; R_{3-5} widely separate from them, but closely approximate at base to each other, R_5 curving away abruptly and R_3 and $_4$ separating more gradualy; M_2 and $_3$ approximate for a short distance; Cu_2 arising from cell at about $\frac{3}{5}$. Hind wing with R and M_1 very shortly stalked, Cu_2 forking off far back toward base of wing, the weak 1st A becoming coincident with it outwardly; inner margin with a large lobe folded under, the edge of the fold reaching up to a row of rough scales along 2d A. Scaling somewhat sparse and raised though far less than in *Heligmocera*, the wing iridescent in a proper light.

Male genitalia (pl. XLV, fig. 22) of the Gymnandrosoma type, with short triangular uncus, closest to *G. aurantianum*, which has also similar secondary sexual characters, but is distinct.

Head and thorax fuscous, with some shining brown scaling, the face blackish; palpi blackish, with top and inner side of first two segments and base of third within, white, contrasting; antenna with under side warm yellow-brown, the scaling blackish, contrasting. Fore wing fuscous, striated and mottled with blackish, gathering to form a broad diffuse median fascia, angled sharply at end

of cell, where there are a few white scales; toward costa fairly defined and followed by a contrasting luteous patch, but below the angle followed by the fuscous ground color, which is crossed by an obscure narrow continuation of the luteous costal patch, extending to the anal angle. Outer margin fuscous and striate, with the striae tending to run obliquely out into the margin; fringe fuscous. The browner portions of the wing have a weak tawny bronze iridescence, most obvious along the costa. Hind wing translucent with slightly raised fuscous scaling, iridescent, toward the costa nearly transparent between the veins. 15 mm.

The caterpillar of the closely related *G. aurantianum* is a borer in oranges.

Porto Rico: El Yunque, 1500–2000 ft., at light, Apr. 22, 1930. Holotype no. 1036 in Collection of Cornell University.

Bactra verutana Zeller

1875. *Bactra lanceolana verutana* Zeller, Verh. z.-b. Ges. Wien, xxv, p. 247.

1924. *Bactra verutana* Forbes, Cornell Mem. lxviii, p. 470.

1926. *Bactra verutana* Heinrich, U. S. Nat. Mus. Bull. cxxxii, p. 84, figs. 47, 171, 346 (genitalia).

Clay color with some fuscous striation, especially on veins, and barring toward the margins; with blackish shade-spots, often obsolete, toward base and end of cell. 11–17 mm.

Larva on Cyperus.

Ontario to Alberta, south to Florida. P. R.: Coamo Springs, April 6–10, San Germán, Apr. 16, Cataño, Apr. 21; May (Leonard and Mills), July 24 (Leonard), San Juan, Aug. 26 (Mills), Aguirre, May 22 and Aug. 1 (Leonard): Puerto Real, Vieques Id., Apr. 28–29 (verified by male genitalia).

Episimus argutanus Clemens (p. 88). Puerto Real, Vieques Id., Apr. 29.

Anchylopera virididorsana Möschler (p. 89). San Germán, Apr. 16, Puerto Real, Vieques Id., Apr. 28–29.

Thiodia autochthones Walsingham (p. 89). San Germán, Apr. 16, Cataño, May 16 (Leonard and Mills). Aguirre, Apr. 2–3, 1931 (Leonard and Mills).

Eucosma strenuana Walker (p. 90). Coamo Springs, Apr. 4–9, Isabela, Apr. 24; Aguirre, Aug. 1 (Leonard); Puerto Real, Vieques Id., Apr. 29.

Crocidosema plebeiana Zeller (p. 91). Coamo Springs, Apr. 4–10, Cataño, Apr. 21, Isabela, Apr. 24, San Germán, Apr. 16, Aguacate, Aguadilla, Apr. 25, Santurce, Mar. 25 (Hoffman); Lares (Seín): Puerto Real, Vieques Id., Apr. 28–29. Common everywhere.

Strepsicrates smithianus Walsingham (p. 91). El Yunque, Apr. 22–23.

Heligmocera calvifrons Walsingham (p. 92), (pl. XLIII, fig. 1; pl. XLV, fig. 23). El Yunque, Mar. 29, Apr. 22–23. The American Museum has a series from Sánchez, Santo Domingo, containing a male; the male palpi are even more extraordinary than Walsingham's description would suggest; they are turned back over the top of the head, with the first segment extending up to the middle of the front, as in Acrolophus, and the third segment resting in a concavity in the vertex. In Walsingham's specimen they had evidently fallen forward.

Epinotia Hübner

Superficially closely similar to Eucosma and Thiodia, the costal fold variable; R_1 of fore wing arising nearer base of wing; male genitalia with uncus developed, socii triangular or strongly chitinized.

Epinotia unica Heinrich

1923. *Epinotia unica* Heinrich, U. S. Nat. Mus. Bull. cxxiii, p. 221, fig. 376 (male genitalia).

Male genitalia (pl. XLV, fig. 24) with a costal spine on valve. Palpus with two blackish spots on upper side of second segment. Fore wing dull ochreous, with irregular fuscous markings, the most definite being a dot at apex, and an oblique bar on inner margin. Expanse normally 13 mm.

Tennessee (U. S. A.). Porto Rico: Isabela, Apr. 24 (undersized).

Phaloniidæ

At the time when Walsingham published his catalogue of the West Indian micros, species in this family were much more inclusively defined than now. I very much doubt if either *P. bunteana* or *lepidana* is actually found in the West Indies. The former is probably based on my new *Saphenista bunteoides*, which according to some interpretations of the code would become the type of *Thyraylia* Walsingham. It completely lacks the pink of the true *bunteana* (as noted by Walsingham) and besides the distinct venation noted by Walsingham has the translucent hind wings with semi-erect scaling shared by all the Saphenistas known to me. It seems best to use Walsingham and Durrant's later name of *Saphenista* for this group.

The majority of Porto Rico species described as Phalonia, are Saphenistas, but *subolivacea* is a true Phalonia similar to *smeathman-*

niana, and *distigmatana* also is a true Phalonia. Besides the species listed below two or three others were taken in too poor condition to describe.

Saphenista Walsingham and Durrant

(*Thyraylia* Walsingham, material studied, but not named type)

Similar to Phalonia, but hind wing (fig. 2) with M_3 and Cu_1 short-stalked, or rarely connate or very shortly separate; translucent, with semi-erect scaling, at least between veins toward costa.

Besides the following species, some of those described as Phalonia should probably be transferred to Saphenista. For this reason a combined key is given.

KEY TO THE REGIONAL SPECIES OF PHALONIIDÆ

1. Hind wing with R and M_1 approximate at base, fore wing with Cu_1 and $_2$ parallel; mottled with tawny, dark brown and cream, the palpi dark; 13 mm. (*Hysterosia ?*) ---------- * *prolectana*
   Hind wing with R and M_1 stalked; smaller ---------- 2
2. Median fascia definite and transverse, passing across cell near end, sometimes broadly interrupted over lower edge of cell; hind wing so far as examined with smooth scaling and M_3 and Cu_1 arising well apart (*Phalonia*) ---------- 3
   Median fascia broad and confused, or diffused and not interrupted, or divided into longitudinal patches; hind wing with translucent areas between veins with semi-erect scaling, M_3 and Cu_1 very closely approximate, connate or short-stalked; see pl. XLIII, g. 2. (*Saphenista*) 6
3. Median fascia olive when fresh, narrow, continuous or slightly interrupted at upper (and lower) edges of cell ---------- *subolivacea*
   Median fascia broad and broadly interrupted over lower edge of cell, dark brown or blackish ---------- 4
   Median fascia very broad and interrupted at Sc; chestnut brown with little or no black scaling ---------- *new species*
4. Fore wing with a brown sub-basal band as well as the brown on base of costa; ground buffy; outer part of wing mainly of the pale ground -- 5
   Fore wing with basal brown at costa only; ground silvery white, the apical part mottled with rusty brown and blackish ---------- * *ichthyochroa*
5. Neck and thorax dark brown; no apical markings mentioned --- * *vicinitana*
   Thorax largely of the light ground; with strong costo-apical spot and other markings at outer margin of wing ---------- *distigmatana*
6. Base of fore wing brown, ending in a dark fascia; median fascia definite on costa, confused below, a distinct stripe across apex ---------- * *lacteipalpis* (St. Vincent)
   Fore wing dark at base only near costa ---------- 7
7. Fore wing dark with a definite subterminal band across apex; costal part of median fascia pointing to end of cell or just beyond ---------- 8
   Fore wing with apical markings suffused, no narrow and definite subterminal fascia; median fascia mottled brown, and continuous ---------- 10

8. Median fascia composed of a costal and dorsal patches as in *distigmatana*, but with the venation of *Saphenista*, the dorsal patch blackish, much darker than the costal ---------- *new species*
   Median fascia represented by longitudinal patches below cell and below fold; markings olive ---------- 9
9. These two olive median patches oval, distinct and each edged above with black ---------- *multistrigata*
   These two patches confused, and only slightly defined with black scales in fold ---------- *semistrigata*
10. Apical region solidly covered with a mixture of brown and black -- *bunteoides*
    Apical region mainly of the light yellowish ground ---------- 11
11. Median fascia defined with whitish before and beyond, and with whitish also in apical region ---------- * *tectonicana*
    Ground light dull ochre, without any white ---------- *lepidulana*

Saphenista bunteoides new species (pl. XLII fig. 3)

1892. *Conchylis bunteana* Walsingham, Proc. Zool. Soc. 1891, p. 501. (?) (not *Conchylis bunteana* Robinson).

1897. *Thyraylia bunteana* Walsingham, Proc. Zool. Soc. 1897, p. 139. (?).

Head and thorax cream, the outer side of the palpus a little darker.

Fore wing with base to ⅖ of costa and less on inner margin cream, with some light brown shading and flecking on costa and faint pink gloss in some lights, but without the decided pink of *Phalonia bunteana*; median area very narrow on costa, meeting it just beyond middle, widening to cover middle half of inner margin; chocolate and yellow-brown mixed, with a good deal of blackish scaling and a few raised lead-colored scales; the middle of the dorsal half mainly of the yellow-brown, so that the band appears forked, but with this patch less obvious than in the North American *P. hollandana* (from Vernonia.) Outer part mainly yellow brown on a cream base, flecked with lead color, with a subterminal band of darker brown mixed with blackish and some lead color, from ⅘ of costa to just above anal angle. The lead color strongest at end of cell, where it forms an ill-defined spot interrupting the postmedian area of the ground. Hind wing translucent fuscous, with some raised scaling, and dark fuscous gray veins. 10 mm.

This resembles the North American *Phalonia bunteana*, and even more closely the Vernonia species which has been mixed with *bunteana* (I believe *hollandana*), and I have no doubt it is the species at first mistaken for *bunteana* by Walsingham. The error was noted in Biol. Cent.-Am., Lep. Het. iv, p. 296. It must resemble *tectoni-*

* The species marked with an asterisk have not been studied and may be placed in the wrong genus.

cana Möschler, which is described as having a yellowish white hind wing.

Porto Rico: Coamo Springs Apr. 9, 10; female type and paratypes, Cornell Univ. no. 1037.

Saphenista lepidulana new species (pl. XLII fig. 4)

1897. *Thyraylia lepidana* Walsingham, Proc. Zool. Soc. 1897, p. 139. (?) (not *Phalonia lepidana* Clemens).

Closely similar to the preceding species, slightly smaller; thorax when fresh rather darker, rather ochreous, outer side of palpi more ochreous; ground of fore wing darker ochreous and more even, the darker yellow-brown more in the form of shades than striations, and with little black and no lead-color. Base with about three brown shades on costa and one on disc, median fascia representing only the basal portion of that of *S. bunteoides*, covering only the second fourth of the inner margin, its upper ⅔ nearly solid brown, but shaded heavily with black toward inner margin; the outer part of the fascia represented by a few black scales at lower angle of cell and on inner margin at ¾. Outer part of wing also deeper ochreous, the subterminal fascia distinct only on costal half, not always scaled with black; the anal angle with some confused mixed brown and black striations. Raised scaling of hind wing appearing as contrasting fuscous dusting. 9.5 mm.

Male genitalia (pl. LXV, fig. 25) with a small simple uncus borne on a large rounded tegumen, a larger simple bluntly pointed gnathos and costa of the valves roundedly prominent, but decidedly less angled than in *S. semistrigata*.

Porto Rico: Coamo Springs, Apr. 5–10, type and paratypes; El Yunque, Apr. 22, paratype; Puerto Real, Vieques Id., Apr. 28, paratype; Cornell Univ. type no. 1038.

Saphenista multistrigata Walsingham-Durrant

1914. *Saphenista multistrigata* Walsingham-Durrant, Biol. Cent.-Am. Lep. Het. iv, p. 296, pl. ix, fig. 5.

Light straw with olive markings, partly defined with black. Palpi white, the second joint shaded with olive on outer side. Fore wing with an olive streak below costa near base, an oblique streak from basal angle to middle of cell, tipped with black, longitudinal oval patches medially along lower edge of cell and fold, each edged above with black, an oblique patch extending down from costa at ⅗, in line with a longer bar extending to anal angle, edged above and especially on outer side with black, a larger fusiform patch extending across apex. Ground more or less suffused and dusted with fuscous, especially along inner margin. Hind wing translucent fuscous, with semi-erect scaling. 7–8 mm.

Male genitalia with uncus obsolescent; gnathos very long, with

truncate bifid apex, and valves slender, strap-shaped, concave upward. (pl. XLV, fig. 27).

Mexico and Jamaica (Walsingham). Porto Rico: Coamo Springs, Apr. 6–10, El Yunque, Apr. 23; Jájome Alto, June 18 (Hoffman).

Saphenista semistrigata new species (pl. XLII fig. 5)

Closely similar superficially to *S. multistrigata,* but in fact nearer to *S. lepidulana.* Fore wing with a defined olive streak running up from basal angle; median fascia divided into three olive patches corresponding to the spots of *S. multistrigata,* the two upper wholly olive, the lower rounded-triangular, with a few black scales representing the black edging of *S. multistrigata;* also a black dot at end of cell. Outer part of wing with more confused olive spots and a couple of black striae near middle of outer margin. 9 mm.

Male genitalia (pl. XLV, fig. 26) with uncus small, with a spherical swelling at base, suggesting a bird's head and beak, scaphium larger, bluntly pointed; valves broad, the costa abruptly bent at middle in an obtuse angle.

Porto Rico: El Yunque, Apr. 22 (type), Mar. 29 (paratype); also paratypes from Coamo Springs, Apr. 4–9. Types no. 1039 in Cornell University.

Saphenista new species. El Yunque, Apr. 23.

Phalonia subolivacea Walsingham (p. 95). Common and general. The Insular Experiment Station has the species bred from *Erechtites hieracifolia.* In old specimens the olive wholly disappears and the markings become a dull red-brown. Male genitalia characterized by a short forked gnathos (pl. XLV, fig. 28).

Coamo Springs, Apr. 4–10, Isabela Apr. 24, Cataño, Apr. 21. El Yunque, Mar. 29, Aguirre, Aug. 1 (Leonard), Apr. 2–3, 1931 (Leonard and Mills); Puerto Real, Vieques Id., Apr. 28–29.

P. distigmatana Walsingham (p. 96). Isabela, Apr. 24.

P. new species. El Yunque, Apr. 22.

Cossidæ

Psychonoctua personalis Grote (p. 97). Coamo Springs, Apr. 4, Cataño, Apr. 21, Aguirre, May 22 (Leonard), Jájome Alto, June (Hoffman), Lares, Sept., Dec. (Seín), Mayagüez, (U. S. Nat. Mus.); Puerto Real, Vieques Id., Apr. 28–29.

Yponomeutidæ

[**Atteva gemmata** Grote

1873. *Oeta gemmata* Grote, Bull. Buff. Soc. Nat. Hist. i, p. 93.
1877. *Oeta fastuosa* Zeller, Horae Soc. Ent. Ross. xiii, p. 25, pl. iii, fig. 68.

1892. *Oeta fastuosa* Walsingham, Proc. Zool. Soc. 1891, p. 533.
1897. *Atteva fastuosa* Walsingham, Proc. Zool. Soc. 1897, p. 113.
1914. *Atteva gemmata* Walsingham-Durrant, Biol. Cent.-Am. Lep. Het. iv, p. 328.
1914. *Atteva gemmata* Meyrick, Lep. Cat. xix, p. 21.

Orange, with over half the surface of the wing covered by areas of blue-black reticulation on a cream white ground, tending to reduce the orange ground to about 6 patches. Larger than the wide-spread *A. aurea* and *punctella* and with far less orange than *A. floridana* Neumoegen, which may be a variety.

Honduras, Cuba. Haiti: Petionville, May–June (Fulda).]

Yponomeuta triangularis Möschler (p. 99). St. Thomas: Charlotte Amalia, Aug. 11 (Leonard).

Plutella maculipennis Curtis (p. 100). Coamo Springs, Apr. 5–7, Isabela, Apr. 24.

GLYPHIPTERYGIDAE

Tortyra aurofasciana Snellen (p. 101). Puerto Real, Vieques Id., July 9 (Leonard).

HELIODINIDÆ

Heliodines quinqueguttata Walsingham (p. 104). Dorado, June 13 (Hoffman); Aguirre, Aug. 1 (Leonard), Apr. 2–3, 1931 (Leonard and Mills).

COSMOPTERYGIDÆ

Cosmopteryx attenuatella Walker (p. 107.) Coamo Springs, Apr. 4. There is a misprint in the bibliography of this species; for *Pyroderces rileyi,* read *Cosmopteryx attenuatella.* The reference is correct. Also read *lespedezae,* not *oe.*

Cosmopteryx antillia new species (pl. XLII fig. 6)

1930. *Cosmopteryx mimetis* Forbes, Sci. Surv. P. R. xii, p. 108. (not *Cosmopteryx mimetis* Meyrick).

Closely similar to *Cosmopteryx mimetis* except in the following points. Antenna with the most basal white ring obsolescent (*mimetis* has two distinct rings separated by one black segment). Fore wing with ground paler orange-yellow, the antemedial silver band only two instead of three scales wide, and less tapering, being of even width practically to costal edge, the black dot beyond it small and standing free of the fascia (in *mimetis* large and mostly embedded in the fascia) and the costal edge contrastingly white before the fascia; silver streak in apex continuous, though not quite meeting the central extension of the yellow median area (in *mimetis* divided into two dashes).

The species looks more like *bambusae* than *mimetis*, but the first fascia is more erect and the tip of the antenna is black. Specimens from Sta. Lucia in the Cornell University collection appear to be still another species, though very closely related.

Porto Rico: Coamo Springs, Apr. 10. Type and paratype Cornell Univ. no. 1040.

C. sanctivincenti Walsingham (p. 108). Coamo Springs, Apr. 9, El Yunque, Mar. 29, Apr. 22.

C. similis Walsingham (p. 108). Coamo Springs, Apr. 4, Puerto Real, Vieques Id., Apr. 29.

Pyroderces rileyi Walsingham (p. 108). Aguirre, Apr. 2–3, 1931 (Leonard and Mills); Puerto Real, Vieques Id., Apr. 29.

Prochola Meyrick

Antenna shorter than fore wing, scape long and slender, without pecten, the outer segments whorled; palpi upturned, the second segment a little rough below at end, third equally long, blade-like, the scales in regular transverse rows, and rough along upper edge; hind tibiae hairy above, with an oblique scale-ridge running down to outer spurs; the longer spurs with combs (as in some species of Aristotelia). Fore wing practically smooth, with cell central, R_4 and $_5$ only stalked, Cu_2 long, 1st A lost, 2d A forked at base; hind wing linear, narrower than in *Perimede*, all veins separate, but M_1 weak and close to R at origin.

A mostly South American genus, apparently close to Perimede. There is also an undescribed species from the Gulf Strip.

Prochola fuscula new species (pl. XLII fig. 7)

Antenna light fuscous, with the raised whorls darker, especially on the somewhat paler apex; second segment of palpus luteous, with a fuscous subterminal band; third fuscous, pale toward base, with the rough scaling mixed with blackish. Fore wing mottled light fuscous on clay color, tending to show striae especially on margins, and faintly iridescent; a black dot in fold and one at end of cell, some blackish scales on inner margin, emphasizing the striae, and on outer margin, corresponding to the veins, also faintly on costa toward apex; fringe concolorous. Hind wing silver gray, with a pale fuscous fringe. Hind tibia with raised scale-ridge luteous, followed by a contrasting blackish shade. 8 mm.

Porto Rico: Puerto Real, Vieques, Id., Apr. 29 (type), Coamo Springs, Apr. 4 (paratype): Cornell Univ. type no. 1041.

Perimede Chambers

Antenna moderately long, the scape long, slender, without pecten; palpus regularly upturned, a little flattened, the second segment thick,

but close-scaled, and third slender. Venation as in Prochola, M_1 of the hind wing normally developed. A small genus, mainly North American, related to *Prochola* and *Ithome*.

Perimede annulata Busck (?).

1914. *Perimede annulata* Busck, Proc. U. S. Nat. Mus. xlvii, p. 2.
1915. *Perimede annulata* Walsingham-Durrant, Biol. Cent.-Am. Lep. Het. iv, p. 406.

Deep bronzy brown-black with four raised scale-tufts on fore wing, an antemedial one in fold the largest. (Antenna with white tip). 11mm.

Cataño, May (Leonard and Mills). The single female has been compared with the type of *annulata*, but is too poor for certainty.

Perimede purpurescens new species (pl. XLII fig. 9)

Umber brown, the thorax and fore wing with a decided iridescence, in most lights violet blue, but changing to crimson; immaculate. Head and first segment of abdomen above paler and grayer; last ten segments of antenna white, contrasting; hind femora and under side of abdomen paler, the legs with obscure paler rings on segments. Under side of wings immaculate, without the dark terminal bars of *P. erransella* and *falcata*. 12 mm.

Porto Rico: Lares, 1930 (Seín); female type, Cornell type no. 1043.

Eriphia Chambers (*Ithome* Chambers, *Eritarbes* Walsingham)

I think there is no question as to the identity of these three names. Chamber's original description of *Eriphia* is hopeless, but fortunately some of the type material survives in the National Museum, and is identical with that of *Ithome unimaculella,* described also in the Can. Ent. two months later. In the description of the latter, Chambers mentions the pale scales on the under side of the third segment of the palpus, which seem to be found in the entire genus. The type locality is Texas, and not Kentucky as stated in Dyar's list, but the Chambers material includes a Kentucky specimen, and Tennessee specimens agree even in genitalia with those from the Gulf strip. I suspect all the species have the pecten with a single bristle, but it is deciduous, and in one or two species I have not seen specimens that had preserved it. There is a clay color under scaling, and rubbed specimens become entirely different in appearance. For venation see pl. XLIII, fig. 4.

The genitalic characters are unique, and in the female there is nothing to compare with them in the entire higher Tineoids. In the male (figs. 29–35) the dorsum is formed mainly of the eighth

abdominal segment, the ninth being reduced to a slender chitinous loop, which is solidly fused at its end to the eighth, and receives its whole strength from it. The uncus may survive as a tiny free point. The eighth segment is also strengthened by a median chitinous rod (shown most plainly in outline in fig. 30). Ventrally the ninth segment (saccus) is reduced to a longitudinal bar, with which the base of the penis articulates, and the 7th and 8th segments are indistinguishably fused, being supported by chitinous bars or a loop, which I suspect really belongs to the 8th segment. The other structures vary enormously from species to species, and are more or less (sometimes extremely) asymmetrical. In the female (fig. 36) the usual hairy lobes of the ovipositor are replaced by a triangular, heavily chitinized piercing blade, with serrate edges, and evidently adapted for laying the egg in the tissues of the food-plant. This structure closely parallels that of the Incurvariidae, to which Busck would relate the genus (in lit.); but I thing the resemblances in other structures to *Perimede* are too deep to be ignored; also I think I can see the vagina and bursa connected with the eighth segment; at least there are specialized chitinous structures at that point, as in other higher moths.

KEY TO SPECIES

1. Apical part of antenna whitish, contrasting ---------- 2
   Antennal shaft all the same color or nearly so ---------- 5
2. Expanse over 10 mm., fore wing with some chestnut scales at a base above and below fold ---------- *conspersa*
   Expanse under 10 mm ---------- 3
3. No costo-apical pale spot, inner third of wing more or less contrastingly paler, yellowish, with a large strongly contrasting black spot (Central America) ---------- *otiosa*
   A contrasting whitish or luteous costo-apical spot, inner margin not yellowish, claviform spot smaller ---------- 4
4. Palpus usually with about 7 contrasting pale scales below, subapical pale spot contrasting in both sexes (U.S.A.) ---------- *concolorella (unimaculella)*
   Palpus with only a few inconspicuous pale spots, costo-apical spot of male obscure ---------- *curvipunctella*
5. Powdery gray, immaculate ---------- *piperatella*
   With distinct pale costo-apical spot or blackish discal spots or both ---------- 6
6. Male with shaft of antenna broadened and wholly light silver gray, conspicuous (in female normal and dark); ground glistening, nearly black with several contrasting pale yellow spots; very small ---------- *pernigrella*
   Male antenna normal, dark and slender; ground grayish, the darker discal spots distinct ---------- 7
7. Abdomen and legs whitish ochreous; antenna, head and thorax with a tawny tint ---------- *tripunctata*
   Legs blackish with white bars; antennae blackish, becoming pearl gray in some lights, but without tawny tint ---------- *quinquepunctata*

Eriphia pernigrella new species

Male with head, body and wings coal black, with a very faint purple iridescence. Palpi very slightly paler on inner side, with a few contrasting whitish scales on under side of third segment; antenna with scape black, the rest thick, and smooth scaled, gray and contrasting. Abdomen with last segment light gray, contrasting, with yellowish side-tufts. Fore wing with small pale costo-apical spot and dorsal spot opposite it, a crescentic or semicircular whitish dot in fold, with a black spot before it, visible only in some lights; discal dot also black, sometimes followed by a few pale scales, nearly invisible. Hind wing and under side of both wings covered with black sex-scaling, only the tuft of bristles on the costa being paler; fringe light gray, contrasting, with buffy iridescence in some lights. Female generally similar without the black sex-scaling; antenna slender, the shaft with black scaling above; abdomen light gray, paler below, hind wings and side gray; outer discal dot on fore wing mere distinct. Fore legs in male black, middle and hind legs with contrasting pale spurs and rings on ends of segments, in female with more extensive pale banding. 6–7 mm.

Male genitalia with eighth segment dorsally very large and hood-like, with a pair of chitinized lateroventral lobes, bearing the lateral scale-tufts at their bases; genitalia proper much reduced, with a large asymmetrical spine. (Pl. XLVI, fig. 29–33 male, fig. 36 female.)

Porto Rico: Puerto Real, Vieques Id., Apr. 28, 29, type and paratypes; Cornell Univ. no. 1044. I have a couple of damaged females apparently of this species from Castries, Sta. Lucia, Sept. 10–22, 1919 (Bradley).

Eriphia curvipunctella Walsingham. I am not sure of my identification, as the only authentic specimen in the U. S. National Museum has lost its abdomen, and Walsingham's description is unusually indefinite; also my few males are in poor condition.

Male genitalia (pl. XLVI), fig. 34) with dorsal lobe of eighth segment small, the lateral ones larger, valves slender, strong with heavy bristles on inner face; a strong crooked unpaired spine on left side, and hooked penis.

Santurce, Mar. 25 (Hoffman), Puerto Real, Vieques Id., Apr. 29; Coamo Springs and Isabela, Apr. (females only).

Eriphia quinquepunctata new species

Fuscous; the scales with contrasting whitish bases and with whitish underscaling, so that the moth becomes steadily paler as it gets rubbed and may become almost clay color. Palpus pale on upper and inner side, with a series of contrasting pale scales on under side of third joint; antenna blackish, with only the tip of the scape contrastingly pale; slender in both sexes. Abdomen much paler, the terminal tufts of male clay color, the dorsal one narrow, and the lateral ones narrow, straight and not very conspicuous. Legs fuscous, banded with clay color at tips of segments; middle and hind legs with a band across tibia also, and with the inner surfaces clay color. Fore wing more or less dusted

by the showing of the pale scale-bases; three black discal dots, each defined with a clay-color dot or bar at its outer end, the one in fold the largest; also pale costo-and dorso-apical spots opposite each other, without accompanying black spots. Fringe gray, hind wing pale clear gray, the fringe duller and with a faint golden ididescence in certain lights. 7 mm.

Male genitalia (pl. XLVI, fig. 35) with dorsal process of eighth segment narrow, not really hood-like; valves slender, each accompanied by a smaller slender process, of which the left member is double; unpaired spine in region of gnathos slender.

Porto Rico: Puerto Real, Vieques Id., Apr. 28–29, type and several paratypes, also a doubtful (rubbed) female from Coamo Springs, Apr. 9. Cornell Univ. type no. 1045.

E. conspersa Walsingham (?) M_1 short-stalked; unicolorous fuscous. 11mm. Lares, July 28 (Leonard). [St. Vincent].

Stilbosis Clemens

Fore wing massively scale-tufted, with two pairs of heavy tufts; antenna moderate; the long scape without pecten; palpi broad, sharp in front but without rough scaling, upturned, with third segment as long as second; hind tibia normal. Fore wing (pl. XLIII, fig. 3) with M_1 long-stalked and R_3 short-stalked, with R_{4+5}; Cu_2 free at base, easily mistaken for 1st A, which is absent; hind wing half as wide; R and M_1 stalked, M_2 and $_3$ connate, the other veins separate.

A small genus, best developed in tropical America. The following species appears to be unique in its solid dark ground.

Stilbosis phaeoptera new species (pl. XLII fig. 8)

Dark umber brown. Head and thorax blackish; second segment of palpus whitish within; antenna with terminal quarter whitish, contrasting; legs dark, with narrow white rings at ends of segments and across middle of tibiae, as usual. Fore wing with blackish tufts: a very large antemedial one across fold, nearly to inner margin, with a small one in the fold just beyond; two median tufts, the upper one twice as large as the lower; and a small tuft at lower angle of cell, besides slight marginal tufts around the apex. Wing practically immaculate, but with a somewhat angulate lead-gray subterminal line visible in some lights. 12 mm.

Porto Rico: Coamo Springs, Apr. 10 (type), El Yunque Apr. 23 (paratype). Cornell Univ. type no. 1042. I have also a specimen from Zanderij I, Boven Para River, Surinam, Apr. 21, 1927, which I cannot distinguish from this species.

Aphanosara new genus

Antenna about ¾ fore wing; scape slender, without pecten; shaft whorled with raised scales outwardly, densely but shortly ciliate between whorls below;

palpi moderate, slender; second segment with a small Mompha-like tuft at tip, third a little shorter, slender and pointed; eyes red; no ocellus; fore tibia stout, with hair-scales extending beyond its tip, hind tibia with bristly hair of even length. Fore wing (pl. XLIII, fig. 5) lanceolate, with tip turned up like many Lyonetiidae; R_4 *free,* from tip of cell, M_1 long-stalked with R_5, M_2 and M_3 connate, Cu_1 separate, Cu_2 well back, 1st A apparently lost; hind wing less than ½, costa hardly sinuate, fringe 3; R and M_1 connate, the rest of the veins separate.

A very striking thing; it is the nearest thing that I know outside of Hawaii to the typical Diplosara group, but is distinguished from all "Diplosaridæ" and all other Cosmopterygidæ of which I have seen any account, by the free R_4 and stalked M_1. The male genitalia are also of Diplosarid type (pl. XLVI, fig. 37), with uncus absent; gnathos paired, the right lobe enormously larger than the left, spirally twisted, and easily mistaken for the uncus; the rest of the genitalia symmetrical, with extra processes arising from the articulation of the valves. The following species is the genotype, and the only Diplosarid in the restricted sense know to me outside of Hawaii.

Aphanosara planistes, new species (pl. XLII fig. 10)

White. Antenna with scape white, basal part of shaft regularly barred with fuscous, apical part with three pairs of black bars, in each case with the first segment bearing a basal and second an apical bar; segments 1–3, 6–7, 10–11, and 14–16 from apex white, 4–5, 8–9, and 12–13 from apex bearing the pairs of black bars. Palpus with black bars near apex of second and third segments, first segment also dark; thorax with yellow longitudinal stripes over junction of disc and tegulae; legs mostly white, front of fore tibia and knee fuscous, with a white line across tibia, fore tarsus with two blackish bars; mid tibia and tarsus with subapical blackish bars.

Fore wing white, with a dull yellow antemedial patch over and below fold, narrowly connected along fold to base, an oblique stripe from costa at ¼ to opposite middle of inner margin, where it is abruptly cut off, and edged by an oblique black bar at its outer angle below the fold; an oblique black striae at middle of costa, a postmedial shade from costa across the wing to lower part of outer margin, diffuse below, where it is bordered by a patch of blackish scales, and defined with a black bar on costa beyond; apex of wing also yellowish, leaving a white post-medial costal triangle. Hind wing nearly white; fringes pale yellowish. 9 mm.

Porto Rico: El Yunque, Mar. 29; type and paratype, Cornell Univ., type no. 1046.

BLASTOBASIDÆ

The U. S. National Museum has specimens of this family with the following biological records, which may serve as a hint in the search for further life-history data. *Valentinia bromeliæ* in plant

rubbish in Bromeliads (Knab); *Auximobasis coffeella* Busck on coffee (Neiva); *Blastobasis lecaniella* on the scales *Lecanium, Ceroplastes* and *Saissetia; Holcocera* sp. boring in grapes on St. Thomas (VanZwaluwenberg):

About 100 specimens were collected of this very difficult family, unfortunately mostly females. The following have been determined with some approach to certainty.

Blastobasis subolivacea Walsingham (p. 112). I have determined as this species a form with the fore tarsus as well as tibia fuscous, pale banded; they are from Coamo Springs, Apr. 6, 10; more doubtful are a pair from Puerto Real, Vieques Id., specimens from Charlotte Amalia, St. Thomas (Leonard), and a very dark specimen from Aguirre.

B. argillacea Walsingham (p. 112). More mottled than the last, with red-brown shading and contrasting fuscous scaling, the ground frequently pale around the first discal dot, and below in a zigzag shade, which defines the dark zigzag mark. Puerto Real, Vieques Id., Apr. 28–29; Coamo Springs, Apr. 5–10, Santurce, Mar. 29 (Hoffman) (female only). St. Thomas; Charlotte Amalia, Aug. 11 (Leonard).

B. new species (?). Light wood brown; fore tarsus wholly pale, contrasting with tibia, etc. San Germán, Apr. 16.

Auximobasis variolata Walsingham (p. 113). Coamo Springs, Apr. 9 (compared with a specimen determined by Walsingham in the National Museum); Puerto Real, Vieques Id., Apr. 28–29.

A. insularis Walsingham (p. 113). This form appears to intergrade with the preceding. Puerto Real, Vieques Id., Apr. 28–29.

A. flaviciliata Walsingham (p. 113). All my female material is *flaviciliata*, male *constans*, but Walsingham claims to have males of both. Puerto Real, Vieques Id., Apr. 28–29. St. Thomas, Mar. 24, 1927.

A. constans Walsingham (p. 113). Puerto Real, Vieques Id., Apr. 28–29.

Auximobasis sp. There are odd specimens of several more species of this genus.

Pigritia sp. (p. 111). A pair which I cannot distinguish offhand from the North American *P. ochrocomella*. Palmas Abajas, 1100 ft., June 23 (male, Hoffman); Coamo Springs, Apr. 10 (female); Lares, July (Leonard).

GELECHIIDÆ

A number of very interesting forms of this family were taken, and the fauna is evidently far from exhausted. The new genus

superficially resembling *Glauce* is particularly interesting, as the genitalia show it to be related to *Eucleodora,* now standing as an *Œcophorid,* and *Blastodacna,* now considered a Lavernid, though its wing characters would cause it to be put in the Gelechiidæ without any hesitation. In fact on superficial examination I had supposed it was a slightly aberrant Glauce, and Busck had been quite willing to call it an Aristotelia.

Tholerostola Meyrick

Tongue present in Porto Rico species (described as obsolete); palpus with second segment thickened with rough scales, third equally long. Fore wing (pl. XLIII, fig. 6) with R_1 weak but traceable, R_4 and R_5 stalked as usual, M_1 free; M_2 and $_3$ stalked, Cu_2 in our species well back from angle, arising before R_2; cell slender, obliquely closed; hind wing with a large hair-pencil in male, covering Sc, notched below apex; M_1 lost, M_2 nearly connate with M_3 near base, Cu_1 somewhat separate; cell open.

The genotype differs specifically in having banded palpi and the fore wing obliquely banded on a gray ground, but also shows the costal pencil. It may be generically distinct from the Porto Rico species, which is tentatively placed here.

Tholerostola evippella new species (pl. XLII fig. 11)

Fuscous and cream white. Head white, with a little fuscous behind base of antennae; palpi with basal half fuscous on outer side; fore and middle legs fuscous in front, barred with whitish, inner faces and hind legs almost all whitish; antennae with scape powdery fuscous, the shaft clay color with the short whorl of scales on each segment largely fuscous. Thorax above whitish in center, fuscous on sides; abdomen dirty clay color. Fore wing shining fuscous brown, with faint iridescence; the dorsal third contrasting cream white; dark area becoming blackish on lower boundary, extending slightly below fold on basal third, and in a very obtuse triangle at middle of wing, on outer third more diffuse, and ending vaguely at anal angle; a few gray scales near inner margin beyond middle, and a small diffuse cream costo-apical spot. Fringe cream opposite costal spot, then powdery fuscous to middle of outer margin, then cream white for a short distance continuing the cream dorsal area, and somewhat grayer, but still very pale below; hind wing pale gray. 7 mm.

Porto Rico: Isabela, Apr. 24 (type); San Germán, Aug. 20 (Leonard) and Coamo Springs, Apr. 5, 7 (paratypes). Cornell Univ. type no. 1047. The U. S. National Museum also has the species from Cuba.

Aristotelia Hübner

The following key will serve to separate the Porto Rico species of Aristotelia at hand, including one not described in this paper.

1. Fore wing conspicuously marked, or dusted with rose ---------- 2
   Fore wing with ground unicolorous, markings slight or faint ---------- 5
2. Conspicuously marked with lead color; fore wing of male below with conspicuous cream sex-scales, enclosed in black ones ---------- *penicillata*
   No lead-colored markings ---------- 3
3. Basal part of shaft of antenna and third segment of palpus *longitudinally* striped with black and white; palpus with third segment very long; antenna with tip not banded (group *roseosuffusella*) ---------- *new species*
   Third segment of palpus and base of antenna transversely banded, antenna white-banded to near tip; third segment of palpus usually little longer than second (group *pudibundella*) ---------- 4
4. Antenna with *alternate* segments toward apex barred; male with costal edge of fore wing plaited, a groove in disc, etc. ---------- *diolcella*
   Antenna with terminal segments all alike, annulate; no striking sex-characters in male ---------- *vagabundella*
5. Antenna with a few segments toward apex with whitish rings, fore wing with black discal dot; palpus nearly plain ---------- *absconditella*
   Antenna without 2 or 3 white-ringed terminal segments; palpus banded, no distinct black discal dot ---------- 6
6. Antenna contrastingly annulate with black and white; fore wing fuscous ---------- *pictiornis*
   Antenna with dark and pale bands of two segments each; wing ochre ---------- *lignicolora*
   Antenna fuscous, not conspicuously marked; fore wing gray, fuscous and tawny ---------- *lycopersicella*

Arstotelia vagabundella new species (pl. XLII fig. 12)

1897. *Aristotelia pudibundella* Walsingham, Proc. Zool. Soc., 1897, p. 66.

1930. *Aristotelia pudibundella* Forbes, Sci. Surv. P. R. xii, p. 116.

(not *Gelechia pudibundella* Zeller)

Head and thorax fuscous, shading to a light wood color or even clay color on the face, somewhat dusted with darker, and with a slight golden iridescence which tends to form three longitudinal stripes on the thorax, but no reddish iridescence. Antenna with scape and pedicel powdery fuscous, shaft blackish, with a white dot of one or two scales on each segment, nearly to the tip, and with a more continuous pale line on the lower posterior side, which also breaks into faint pale dots toward apex. Palpus blackish, with three white rings on second segment, the last one terminal, and three on third segment, leaving the base and tip blackish; the rings broader on the upper inner side, where the first two normally fuse. Fore femur and tibia blackish with slight transverse bars, the tarsus with clay colored bars near base and at tip of first segment, and at

tip of second, but third as well as fourth entirely dark. Middle and hind legs with the usual more extensive light markings. Abdomen concolorous fuscous, paler and banded below, with the terminal tuft contrastingly pale, but more or less completely withdrawn into the next to last segment.

Fore wing above with ground fuscous gray, somewhat powdery and mottled, becoming nearly black near costa; before the first and after the second and third fasciae inner margin below fold heavily shaded with dull ochre or wood brown, with a faint brassy iridescence, mostly leaving the extreme margin gray; the ochre extending up to below end of cell, where it makes a spot, and more narrowly along the very oblique outer margin nearly to apex. Fasciae essentially as in *A. roseoffiusella,* black-brown, and not contrasting with the darker portions of the ground, the first fascia rather narrow, diffuse basally, the first and second ending in black bars along the fold; second fascia not extending up and out into the disc, but followed by a smallish black first discal dot; third fascia subtriangular, obscure, ending below in the bar-like outer discal dot, which bounds the ochre outer spot above; center of apical part of wing shaded with blackish, the outer part of costa and apex surrounded with a series of alternate whitish and black bars. Fringe luteous subapically opposite R_2 and R_3, where it continues a relatively pale portion of the ground, then mouse gray to apex, where it is continued by a dark basal shade to near middle of outer margin, outer part of dorsal fringe and whole fringe toward anal angle pale fuscous, with some dark tips at apex. Hind wing gray, with nearly concolorous fuscous fringes; under side fuscous, with the pale subapical spot of the fore wing obscurely repeated. No obvious sexual modifications, the costa of the hind wing with a few stiffer hair-scales to represent the hair pencil of *A. diolcella.* Sexes similar. There is some variation, especially in the amount of fuscous dusting and of yellow. 9 mm.

Male genitalia with uncus short (pl. XLVII, figs. 40, 41) and stout; subscaphium weak, tegumen with a concave surface near exit of aedoeagus, clothed with a brush of short stiff bristles; valve slender, nearly cylindrical, basally apparently fused with the fused saccus and juxta, which terminates in a pair of triangular chitinizations; nearly simple toward apex; aedoeagus stout, blunt, unmodified. Intersegmental membrane with a fringe of pale short hair-scales, and a large fanlike tuft on each side.

Porto Rico: Puerto Real, Vieques Id., Apr. 28–29 (type and many paratypes); Isabela Apr. 24 and Coamo Springs, Apr. 4–10, Aguirre, Apr. 2–3, 31 (Leonard and Mills) (paratypes). Cornell Univ. type no. 1048. The species has not yet been seen outside of Porto Rico.

Aristotelia diolcella new species (pl. XLII fig. 13)

1897. *Eucatoptus rubidella* Walsingham, Proc. Zool. Soc. 1897, p. 70.
1930. *Aristotelia rubidella* Forbes, Sci. Surv. P. R. xii, p. 117.

(not *Gelechia rubidella* Clemens)

Head and thorax mottled or powdery fuscous, the head paler, and sides of thorax blackish with a row of pink splashes; tegulae blackish; antennae on basal part fuscous, somewhat annulate, each alternate whorl of scales marked

with a whitish scale above; last ten segments with a stronger white bar on each alternate *segment*, then two black segments intervening beyond the enlarged white bar which ends the basal series. Palpus blackish, the second segment with three whitish bars, the third with three rings, both more or less pink in fresh material; terminal ring subapical on outer side but apical on inner side of palpus. Fore tibia with pink bars, tarsus with white rings on base of first segment and tips of all except fourth. Abdomen fuscous above, transversely barred with clay and fuscous below, somewhat paler than in *vagabundella;* male genitalia sometimes everted, then showing plainly the scoop-shaped uncus and narrow spatulate valves.

Fore wing dark fuscous, powdery, with numerous scattered bright pink scales, but obscure markings; first fascia nearly obsolete, second black-brown, obscure, cut off abruptly in male by the clay-yellow upper slope of the ridge which on the upper side represents the pocket for the hair-pencil; third fascia obsolescent, represented by some browner shading, extending down to the black second discal spot; 1st discal spot also black and inconspicuous; some yellowish scales at basal angle, defining the lower sides of the two discal spots, and subapically. Fringe blackish, barred with pink on the costa, the series of bars continued in the base of the dorsal fringe, outer part of dorsal fringe fuscous.

Male beneath with the costal edge plaited from base to ⅔, the plait clothed with dense rough clay-yellow sex-scales, general surface fuscous, paler toward base, the fringe barred with fuscous and clay color. Hind wing fuscous, normal, the costa with a large expansible hair-pencil, normally contained in a groove below the cell of the fore wing, which involves the material from the fold to the anal vein. Female similar, without the secondary sexual characters, the second fascia of the fore wing above generally less obscure, and crossing the fold. 8 mm.

Male genitalia with a scoop-shaped uncus, truncate at the tips, the valve spatulate with an angle on its lower edge at half length, and abruptly bent up; gnathos long and spine-like; penis simple, pointed. (Pl. XLVII fig. 42.)

Porto Rico: Puerto Real, Vieques Id., Apr. 28–29 (type and numerous paratypes); Coamo Springs, Apr. 9; San Germán, Apr. 16–17; Palmas Abajo, June 23 (Hoffman) (paratypes). Cornell type no. 1049. Also specimens from Trinidad in the U. S. National Museum (Busck), show the same essential characters but are a little more contrastingly marked.

Aristotelia absconditella Walker

1864. *Gelechia absconditella* Walker, List Lep. Ins. B. M. xxix, p. 595.
1903. *Aristotelia absconditella* Busck, Proc. U. S. Nat. Mus. xxv, p. 801.
1924. *Aristotelia absconditella* Forbes, Cornell Mem. lxviii, p. 296.
1925. *Aristotelia absconditella* Meyrick, Gen. Ins. clxxxiv, p. 45.
1872. *Gelechia palpiannulella* Chambers, Can. Ent. iv, p. 68.

Fuscous; antenna with a few scattered segments toward apex whitish, contrasting (usually the 5th and 10th from apex, but occasionally with some additional ones); palpus with tip of second

segment and some shading on third pale, unlike *lycopersicella,* which has a banded palpus. Fore wing with a faint pale oblique subapical costal dash and a black dot at lower angle of cell only; a broken dark line in fringe around apex. 8 mm.

Male genitalia (pl. XLVII, fig. 44) from a Connecticut specimen. Larva in stem of Polygonum, often forming a slight gall.

U. S., west to Kansas. P. R.: Coamo Springs Apr. 4, 10 (both female).

Aristotelia lignicolora new species (pl. XLII fig. 14)

Hind wing with M_2 curved and approximate to M_3 at base as in *Glauce* (and Gelechia etc.). Hind tibia with a fringe of long spines on each of the longer spurs, regularly decreasing in length and not reaching the end of the spur, better developed on upper spur; longer midtibial spur with a weaker fringe. (This comb is shared by *pyroderceia, picticornis,* and *Glaucacna iridea,* described below; but is absent in more normal species of Aristotelia.)

Antenna with scape dusted and basal two-thirds of shaft annulate in clay color and fuscous, the outer part mostly blackish, with three pairs of segments broadly annulate with clay color, producing three pale bands (segments 2 and 3, 6 and 7, 10 and 11 from apex). Clay color; palpus with two powdery fuscous transverse bars on each segment; fore and middle tibiae and tarsi fuscous with clay bars, hind tibia clay color, lightly dusted with fuscous, and tarsus barred, but with the light color dominant. Head and thorax also clay color, dusted and shaded with wood brown. Fore wing clay color, with the wood brown dominant in outer part of disc and at lower angle of cell; lightly dusted with fuscous scales, especially along fold and margins, the outer margin with a nearly continuous line in base of dorsal fringe, costoapical margin and base of fringe with obscure bars of blackish dusting, outer fringe powdered fuscous on a clay base. Abdomen, hind wing and dorsal fringe of fore wing mouse gray. 9 mm. Male genitalia characterized by an enormous penis (pl. XLVII, fig. 43).

Porto Rico: Coamo Springs, Apr. 9; type no. 1050, in Cornell University collection.

Aristotelia picticornis Walsingham

1897. *Aristotelia picticornis* Walsingham, Proc. Zool. Soc. 1897, p. 68.
1925. *Compsolechia picticornis* Meyrick, Gen. Ins. clxxxiv, p. 121.
1930. *Anacampsis picticornis* Forbes, Sci. Surv. P. R. xxi, p. 125.

Having taken a true Aristotelia with the characters given by Walsingham for *picticornis,* I refer the species back here. It shows chalky whitish sex-scaling on the disc of the fore wing below and hind wing above, and traces of a costal hair-pencil; also combs on the spurs. The buffy dorsal fringe mentioned by Walsingham is distinct.

Coamo Springs Apr. 6, 10, (male, female).

Aristotelia penicillata Walsingham (p. 117). Coamo Springs, Apr. 9, Isabela, Apr. 24. Shows the "*Eucatoptus*" hair-pencil very strikingly.

Glaucacna new genus

Antenna shorter than fore wing, without pecten; palpus with second segment somewhat rough below, but not tufted, third segment slender, a little shorter; middle tibia with a few loose bristly hairs above, the spurs unarmed; hind tibia with bristly hair above; *the upper spurs at one-third* (below middle in the similar Gelechiidae); the longer upper spur very long, with a strong comb of bristles, the longer terminal one hardly ⅔ as long, with weaker comb. Fore wing Gelechiid-like, with all veins, R_4 an R_5 stalked, M_1 free, M_3 and Cu_1 widely spaced; M_3, Cu_1 and Cu_2 very short, hardly longer than the space between them, the cell being close to the inner margin, though obliquely cut off, and not as in *Blastodacna;* hind wing with a large sex-tuft partly of spinelike bristles, and partly of large scales, much as in *Glauce;* M_1 and M_2 obsolescent, apparently both free; M_3 about as far from Cu_1 as it is from Cu_2.

This is a fantastically aberrant genus; the hind wing has the long drawn-out apex of a specialized Gelechiid, from which it differs superficially only in the high hind tibial spurs; the male genitalia are as in *Blastodacna*, *Chaetocampa*, *Parametriotes*, and some aberrant "*Batrachedras*", now standing as Laverdinae, as in *Durrantia*, now considered a Gelechiid or Xylorictid, and as in *Eucleodora*, now standing as an Œcophorid, which Busck figures as having a similar Gelechiid hind wing, though quite different in the fore wing, but which Meyrick figures with a simple hind wing. The most obvious common character is the pair of gnathos-lobes which are spatulate or knobbed and bear transverse rows of bristles in all these superficially very different genera. The known larvæ have dense secondary hair, unlike any other true micro, and feed on various plants: Crataegus, Croton, Coca and tea.

Glaucacna iridea new species (pl. XLII fig. 15)

Dull ochre. Antenna with base fuscous, obscurely annulate; middle with four alternating bands of fuscous and ochre, each of 2½ segments; apex fuscous with an ochre band on every alternate segment, five in all besides the ochre tip. Palpi with two heavy fuscous bands on second and third segments, on the second nearly covering the surface; head and front of thorax and shoulders darker ochre. Fore wing with basal half ochre, third quarter of wing wood brown on costal ⅗ and ochre below, a blackish spot on costa at middle, from which a wood brown shade-streak extends obliquely in toward inner margin, broadening and becoming very faint toward margin; apical quarter wood brown, mottled, with a blackish discal dot, connected by a dark brown shade to inner margin, and a blackish dorso-apical shade, extending down into fringe; costal and apical fringes

concolorous, dorsal fringe and hind wing with its fringe gray. Hind wing with an expansible pencil of long yellow hairs, outwardly mixed with long spatulate scales, and with some narrow raised scales on the wing-surface below it.

Male genitalia (pl. XLVI, figs. 38, 39) easily distinguishible by the paired spatulate gnathos-lobes with regular series of bristles. 8 mm.

Porto Rico: El Yunque, Apr. 22–23, type and three paratypes, Cornell Univ. type no. 1051.

Empedaula Meyrick

Similar to *Aristotelia*. Second and third segments of palpi blade-like, much wider than in Aristotelia, with a crest of scales on posterior (upper) side. Fore wing more pointed than in Aristotelia, with outer margin bisinuate. Essentially the same pattern occurs in the North American *Aristotelia salicifungiella*.

Empedaula rhodocosma Meyrick

1914. *Aristotelia rhodososma* Meyrick, Trans. Ent. Soc. Lond. 1914, p. 229.

1925. *Empedaula rhodocosma* Meyrick, Gen. Ins. clxxxiv, p. 48.

Palpi whitish with about three diffuse brown bands on second and third segments. Powdery gray, fore wing with a broad oblique chocolate band from before middle of costa, followed by a parallel gray band which is edged with rose scaling, and preceded by a paler shade, which is continued along costa to base, leaving a darker gray triangle on inner margin; outer part of wing much shaded with light gray and pink, with a tendency to longitudinal streaking; the costoapical portion dark. 8 mm.

Guiana, Brazil, P. R.: Coamo Springs, Apr. 10, San Germán, Apr. 16.

Eucordylea Dietz

Closely similar to *Recurvaria* (p. 117). Palpus with second segment rather straight, with a large expansible tuft on inner side (female unknown, presumably without the tuft), third segment considerably shorter. Genitalia essentially as in Recurvaria. In the Porto Rico species M_3 and Cu_1 of hind wing are shortly separate.

I have one species from San Germán, in too poor condition to describe satisfactorily.

Epithectis eromene Walsingham (p. 119). Coamo Springs, Apr. 7–10, Santurce, Mar. 25 (Hoffman); Aguirre, Apr. 2–3, 1931 (Leonard and Mills); also a pale strain apparently of the same species from Puerto Real, Vieques Id., Apr. 28–29.

E. annulicornis Walsingham (p. 119). In this species, while the normal extent of the dark marking is less, leaving the discal dot isolated, the palpus has more fuscous on the second segment, often obscuring the bands, which will distinguish this species from abnormally light ones of the preceding. Larva in nest of *Polistes annularis* (Meyrick, Exot. Micr. i, p. 198).

Coamo Springs, Apr. 4–10, Puerto Real, Vieques Id., Ap. 28–29.

I have several (2 or 3) other species of Epithectis undetermined; among them I think I recognize *E. kittella* Walsingham, from El Yunque.

Schistophila Chretien

Palpus with second segment broadly rough-scaled below, third somewhat shorter, stout and slightly rough below, but pointed; fore wing with raised tufts in fold, with M_1 long-stalked, M_2 to Cu_1 long and nearly parallel, Cu_2 (at least in the Porto Rico species) shorter and a little separated. Hind wing with R and M_1 long-stalked, M_2 curved and approximated to M_3, which is shortly separated from Cu_1.

This genus is transitional between Recurvaria, Epithectis and Telphusa. The only described species (from southern Europe) is reported to have M_3 and Cu_1 remote, and is perhaps generically distinct, but occupies the same general position.

Schistophila fuscella new species

Head and thorax luteous with some light gray scales. Antenna fuscous, annulate with luteous, the annulations toward the tip on every other segment; palpus with outer side of two fuscous, with subapical and apical luteous bars, inner side mostly pale, third segment with two luteous rings and a luteous tip, on a fuscous base. Fore wing with tufts on lower edge of cell at 1/8, 3/8 and at end, and corresponding ones on fold, also one at upper angle of cell; mottled fuscous and dull reddish brown on a luteous base; a black line on lower edge of cell from 2d to 3d tuft; fold contrastingly blackish out to first tuft; base of costa blackish, and a blackish shade along third quarter of costa, abruptly cut off at 3/4. Base of fringe barred with black and luteous, with obscure corresponding bars representing terminal line. Hind wing whitish in disc, light fuscous along costal edge and on outer third; dorsal half to end of cell luteous (apparently sex-scaling) shading into the fuscous outwardly. 11 mm.

Porto Rico: El Yunque, Apr. 22; Cornell Univ. type no. 1054.

Telphusa Chambers

Palpus with second segment rough-scaled below as in Gelechia, third slender, normal; fore wing more or less distinctly scale-tufted; venation normal, with R_4 and $_5$ only stalked in fore wing and Cu_2 long; hind wing notched below apex, with R and M_1 approximate,

connate or stalked, M_2 curved and approaching M_3 at base, M_3 and Cu_1 rather shortly but distinctly separate.

A nearly world-wide genus with about 100 species. Two or three more are known from the West Indies.

Telphusa perspicua Walsingham

1897. *Gelechia perspicua* Walsingham, Proc. Zool. Soc. 1897, p. 72.
1925. *Telphusa perspicua* Meyrick, Gen. Ins. clxxxiv, p. 70.

Black-brown, contrastingly marked with yellow, which tends to surround some of the blackish areas and form broken ocellate spots. Three or four raised yellow tufts. Yellow strongest on head, scutellum, and a subapical costal spot. Palpus blackish, banded with yellow. 10 mm.

Haiti. P. R.: Coamo Springs, Apr. 6–10; Puerto Real, Vieques Id., Apr. 28.

Telphusa distictella new species

Similar to *T. glandiferella*. Light dull gray. Palpus with second segment blackish, contrasting, third blackish with two narrow pale lines of dusting on outer side, pale with powdery blackish bars on inner; antenna contrastingly annulate with blackish. Shoulders blackish; legs blackish, narrowly barred with cream at segments, the hind leg paler as usual. Fore wing with the black spot a third way out on inner margin nearly as wide as high, and preceded by a smaller triangular spot at basal angle; a small black dot at lower angle of cell; base of costa with a blackish patch, extending almost continuously to ¼, middle of costa with small blackish dots, alternately larger and smaller, and a larger blackish spot at ⅔; outer part of costa and outer margin barred with small blackish shades; fringe light gray, its base obscurely barred with darker gray. Hind wing with its fringe, and abdomen mouse gray. 10 mm.

Porto Rico: San German, Aug. 20, 1930 (Leonard) Cornell Univ. type no. 1053.

Trichotaphe (p. 120). It is probably best to use this name in the more extended sense generally familiar, and include *Cymotricha*, *Onebala* (*Helcystogramma*) and *Thelyasceta* as subgenera. *Dichomeris*, also treated as congeneric by Durrant, is a little more distinct and may well be held as a genus. Of the three species here added to the Porto Rico list, the first is a Cymotricha, having a well developed fringe of hair on the base of Cu, and the other two would belong to Onebala, with the second segment of the palpus smooth scaled, and R_5 running to the apex.

Trichotaphe (Cymotricha) pectinella new species

Deep iron gray, with faint bronzy iridescence. Antenna very faintly annulate; palpus with second segment contrastingly whitish along the upper side

of the truncate tuft, at apex; third segment pale, blackish along under side and at tip only. Fore wing with costal edge clay color and contrasting, except toward apex; three black discal dots, the first two vertically placed, defined with clay yellow scaling on the outer side of the first one in the cell, before and at the lower outer angle of spot at end of cell, and on outer side of spot in fold; a smaller spot in cell at ⅓, without yellow edging; hind wing the usual gray, with a strong tuft of hair on Cu.

Porto Rico: Coamo Springs, Apr. 10; Cornell Univ. type no. 1055.

Trichotaphe (Onebala) elliptica new species (pl. XLII fig. 19)

Ash gray. Palpus cream yellow, contrasting; legs yellowish white, the outer sides of tibiae banded with light gray. Fore wing with markings blackish, defined with light yellow, a half-oval patch on inner margin, extending nearly across the cell; a small horizontally elongate patch at end of cell, and a blackish costo-apical area, defined on basal side with a strong pale yellow streak, which fades out near middle of wing, the dark patch extending vaguely to anal angle. 11 mm.

This species belongs to the tropical group frequently called *Helcystogramma;* it seems to come nearest to *T. symbolica* Meyrick (Gen. Ins. clxxxiv, pl. iii, fig. 58), but in the latter the pale edging of the apical patch is double, the patch on the inner margin is differently shaped, and the one at the end of cell is replaced by a group of two or three.

Porto Rico: Puerto Real, Vieques Id., Apr. 28; Cornell Univ. type no. 1056.

Trichotaphe (Onebala) melissia Walsingham

1911. *Dichomeris melissia* Walsingham, Biol. Cent.-Am. Lep. Het. iv, p. 97.

1925. *Cymotricha melissia* Meyrick, Gen. Ins. clxxxiv p. 189.

1921. *Lecithocera emigrans* Meyrick, Exot. Micr. ii, p. 435.

1925. *Brachmia emigrans* Meyrick, Gen. Ins. clxxxiv. p. 249.

Deep bronzy umber brown; palpus with second segment broadly and somewhat roughly scaled below, with a ridge-like tuft directed inward along its upper edge, concolorous with a fine yellowish streak on inner face of third segment. Thorax with a contrasting fine yellow V, crossing tegulae obliquely and with its apex on scutellum, as in *T. (C.) trigonella.* Fore wing with fine yellowish markings, and sometimes a chocolate patch over cell and fold beyond middle of cell; base of inner margin cream. 12 mm.

Typical (mainland) specimens differ somewhat, but Busck reports them as having the same genitalia. I am also indebted to him for the synonymy above, and for the biological notes. The species belongs to a different group from the preceding, and appears related to the

South American *T. meconitis* Meyr. Larva a pest on sweet potato (Bourne and Otero).

Panama; Barbados (Bourne, U. S. N. M.). P. R.: El Yunque, Apr. 22; Río Piedras, Jan. 10, 1931 (Mills).

Dichomeris piperatus Walsingham (p. 121). Coamo Springs, Apr. 6, Santurce, Mar. 25 (Hoffman), Cataño, Apr. 21, Isabela, Apr. 11 (larva tying leaves of alfalfa—Exp. Sta.), Puerto Real, Vieques Id., Apr. 29.

D. indignus Walsingham (p. 121). Coamo Springs, Apr. 7, El Yunque, Mar. 29, Apr. 22, 23, Jájome Alto, June 18 (Hoffman).

Thiotricha sciurella Walsingham (p. 122). Puerto Real, Vieques Id., Apr. 28.

Polyhymno luteostrigella Chambers (p. 123). Río Piedras, Apr. 23 (Leonard), Cataño, Apr. 21, Isabela, Apr. 24, Lares, Sept. 20 (Seín), Río Piedras, Sept. 21 (Leonard); Puerto Real, Vieques Id., Apr. 29.

Brachyacma palpigera Walsingham (p. 123). Bottimer reports it from Vachellia, in Texas, in Jour. Agr. Res. xxxiii, p. 812, and gives further references. Coamo Springs, Apr. 5, Puerto Real, Vieques Id., Apr. 28, 29.

Anacampsis Curtis (p. 124). Several additional species were taken of this genus besides the following, but not in condition to describe; I suspect one is *mangelivora* and at least one is new.

REVISED KEY TO SPECIES

1. Palpus with loose hair or a more or less triangular tuft on second segment above ---------- 2
   Palpus closely scaled throughout; normally with R_4 and R_5 merely stalked *(Compsolechia)* ---------- 6
2. Fore wing with a vein lost, R_4 and R_5 being completely united; fuscous with a blackish antemedial shade across fold, and no discal dot or postmedial markings *(Commatica)* ---------- *bifuscella*
   Fore wing with R_4 and R_5 stalked *(Anacampsis)* ---------- 3
3. Gray with three whitish costal patches, and third segment of palpus gray; 8 mm ---------- *insularis*
   No pale costal patches, merely a pale postmedial line and blackish dots ---------- 4
4. Fore wing with three diffuse larger dark spots, first across fold, second and third the usual discal dots; 13 mm ---------- *lapidella*
   Fore wing with the spot in fold and three on costa alone conspicuous; palpus three-banded ---------- *new species*
   Fore wing with five small spots, including one at base of costa; palpus with third segment white; ground paler; 10–12 mm ---------- 5
5. Third segment of palpus triannulate; antenna distinctly annulate ---------- *new species*

Second segment of palpus with only basal two thirds black--------*cornifer*
Second segment of palpus blackish with pale apex only--*quinquepunctella*

6. Thorax and base and apex of fore wing black, contrasting----*new species*
Thorax and base and apex of fore wing concolorous-------------------- 7

7. Antenna black and white-------------------(see *Aristotelia picticornis*)
Antenna grayish, annulations obscure--------------------------------- 8

8. Antenna and palpus more or less gray on yellow; legs yellowish white, hind tibia with a black bar below; fore wing gray with a black patch at basal angle, and no pale even costoapically----------------*desectella*
Antenna gray; palpus not yellowish; no basal spot; a pale spot or transverse line at base of costal fringe if any markings are present--------- 9

9. Postmedial line sharply defined and bilunulate------------------------- 10
Postmedial line faint or diffuse--------------------------------------- 11

10. Apical fringe with two contrasting black bars--------------*meibomiella*
Apical fringe not specially marked (Jamaica etc.)------------*succincta*

11. Expanse 14 mm.; ground powdery, second segment of palpus black, no darker dots on fore wing--------------------------------*mangelivora*
Expanse 10 mm.; ground shining; first segment of palpus black only; five discal and terminal dots----------------------------*plumbeolata*

Anacampsis (Commatica) bifuscella new species

Palpus with second segment triangularly scaled, the broad scaling mostly above, third segment about ⅓ longer. Fore wing (pl. XLIII, fig. 7) with R_4 and R_5 completely united; hind wing with R and M_1 well separated at base, but strongly divergent; M_3 and Cu_1 slightly separated.

Ash gray, faintly yellowish and powdered lightly with fuscous scales. Antenna lightly annulate in two shades of gray; second segment of palpus fuscous on outer side and below, tip narrowly white, and tuft and upper side more extensively whitish, third segment slender and whitish, darkening toward tip. Legs light gray, paler-banded. Fore wing with more or less distinct antemedial shades on costa and fold, and middle of costa also shaded with blackish; a strong oblique fascia from cell to or nearly to inner margin, broadly interrupted below the cell, cutting off a rounded spot in cell; a small blackish discal dot, with some dark shading between it and anal angle, and short terminal dashes or elongate dots sometimes connected by a wavy terminal line; fringe warmer and more brownish, with a darker brown central line. Hind wing gray. 8 mm.

A rather distinct little thing. By its structures it would go in Meyrick's genus *Commatica*, but the latter normally has the fine white postmedial line, and I suspect it may be a parallel development from typical Anacampsis.

Porto Rico: Coamo Springs, Apr. 5–10, type and paratypes, San Germán, Apr. 16, Isabela, Apr. 24, El Yunque, Apr. 22–23. Cornell Univ. type no. 1057.

A. (Anacampsis) insularis Walsingham (p. 125) El Yunque, Apr. 23.

A. (A.) new species. Santurce (Hoffman), San Germán.

A. (A.) new species. San Germán.

Anacampsis (Compsolechia) melanophaea new species (pl. XLII, fig. 16)

Palpus close-scaled, the second segment hardly thickened, third slightly longer. Hind wing bluntly trapezoidal, without fringe on Cu.

Head and body brown-black; palpus with a narrow whitish ring at tip of second segment, third pale on inner face; antenna annulate in two shades of fuscous; scutellum shining buff, contrasting; legs with the usual pale rings, and hind legs paler. Fore wing buff with golden iridescence in male, shading through chestnut into blackish on costa and inner margin, the shades extending about half the length of the wing, the costal one centering a little beyond the middle of the wing, and dorsal one a little before. Base of fore wing black, contrasting, the area extending to basal angle in male, shorter in female; basal half of costa shaded with fuscous in male, connecting the black base and median shade; apex also black, the boundary extending from 5/6 of costa to above anal angle in male, in female more oblique and with incurved inner boundary; female only with a dot in outer part of cell. 13 mm.

I am not quite sure the two specimens are conspecific and make the male the type; the female differs mainly in its duller color, more definite markings, and slightly more restricted black base and tips. The characters if construed strictly would run the species to *Melitoxestis* Meyrick, an African genus.

Porto Rico: El Yunque, Apr. 23 (male type); Coamo Springs, Apr. 9 (female paratype). Cornell Univ. type no. 1058.

Anacampsis (Compsolechia) meibomiella new species (pl. XLII fig. 17)

Light ash gray. Head and thorax rather darker. Antenna blackish above, with a white dot of a couple of scales on each segment, golden below; second segment of palpus smooth but broadly scaled, with a tendency to transverse seriation of the scaling, but no banding, third segment hardly longer, slender; palpus white, shaded on outer side with gray, the third segment with slender black and white stripes, at least toward tip. Legs dark gray, cut with white. Fore wing pale gray, slightly shining and a little powdered and shaded with white; base of costa and of A blackish; two black antemedial spots which may fuse across the fold, and a point in fold beyond them, and one below fold a little further out; middle of costa with an oblique black band, shaded and extended with bronze brown and ending overlapping the outer side of an oblique black and bronze streak across lower part of cell and sometimes fold; a small black dot at end of cell; outer line somewhat angled at middle, concave above and below, fine and pale and preceded by a broad bronze band, which is defined outwardly with black, at least at costa, and followed by blackish and bronze at costa; marginal area with a cream white longitudinal dash from postmedial band to just above apex and with pale longitudinal streaks dorsally; margin with two heavy black bars below apex, defined and separated by smaller white bars, and preceded by a faint bronze shade; fringe with base golden, outer part gray, separated by a blackish subbasal line. Hind wing gray. 9 mm.

Apparently close to *repandella*, the type of *Compsolechia*, but distinguished by the two black marginal bars from the other species known to me, and from most of this group by the absence of striation on the palpus. The Porto Rico specimen (figured) is paler, smoother looking and more lightly marked than the types from Cuba, but the markings are identical.

Cuba (no. 9454) bred from *Meibomia* in U. S. National Museum, also a collected specimen from Santiago (type and paratypes). Porto Rico: San Germán, Apr. 16, paratype No. 1059 in Cornell University.

A. (C.) mangelivora Walsingham (p. 125). El Yunque, Apr. 23 (?). Too poor for certainty.

A. (C.) plumbeolata Walsingham (p. 125). Coamo Springs, Apr. 10, apparently not typical.

Phthorimaea Meyrick (p. 125) will probably have to be sunk to *Gnorimoschema* Busck which has priority. All the Porto Rico species yet known belong to Phthorimaea.

P. operculella Zeller (p. 126). This species sometimes has the white scale-tips more normal in Gnorimoschema; perhaps always when perfectly fresh. *P. gudmannella*, as identified in the National Museum, is much smaller, and more contrastingly mottled, with the cream-white ground visible in considerable areas, especially toward the apex. Coamo Springs, Apr. 6–10, Isabela, Apr. 24, San Germán, Apr. 16, Jájome Alto, June 16 (Hoffman); Puerto Real, Vieques Id., Apr. 28.

P. striatella Murtfeldt (p. 127). Cataño, Apr. 21.

Gelechia salva Meyrick (p. 126). If I have this species determined correctly it is a true Gelechia, with third segment of palpus slender, and R and M_1 of hind wing stalked. Coamo Springs, Apr. 4–10, San Germán, Apr. 16.

Stegasta capitella Fabricius (p. 129). Coamo Springs, Apr. 4–10, Isabela, Apr. 24, San Germán, Apr. 16, Aguirre, April 15, Cataño, May 16 (Leonard and Mills); Río Piedras, Aug. 8 and Lares, July 18 (Leonard), Aguirre, Apr. 2–3, 1931 (Leonard and Mills); Vieques Id., Apr. 28–29. A common species. For venation see pl. XLIII fig. 8.

S. bosquella costipunctella Möschler (p. 128). The Porto Rico form as seen in series is a distinct race, with the pale part of the fore wing varying from pink to an almost concolorous gray; none of the specimens show the clear orange of typical *bosquella*. Specimens in the U. S. National Museum from Santo Domingo are typical

bosquella, but some from South America approach the Porto Rico form. San Germán, Apr. 16, Puerto Real, Vieques Id., Apr. 28–29.

[*Platyedra gossypiella* Saunders (p. 129). Haiti: Petionville, June 13, (Fulda); Santo Domingo: Monte Cristi, Apr. 4–5, bred from cotton boll,—Ins. Exp. Sta.]

XYLORICTIDÆ

The following species was described as a *Gelechiid,* and is so treated in the preceding paper (p. 120), but in fact is a member of a small New-World group of aberrant Xylorictidæ, typified by the genus *Durrantia.* Œgoconia may possibly also be related. In placing the Antillian *Brachmia fulvidella* Wals, in Paranoea, Meyrick obviously mistook the rudiment of 1st A for Cu_2; *Paranœa latescens,* the genotype, is a true Gelechiid.

Schistonoea new genus

Head and thorax smooth with decumbent scaling, palpus close-scaled, upturned beyond vertex, with third segment practically as long as second, slender and pointed; tongue normal, ocellus absent; hind tibia with loose hair. Fore wing (pl. XLIII, fig. 9) oblong, four times as long as wide, R_1 arising beyong middle of cell, R_2 nearer R_1 than R_3, which is stalked with R_{4+5}, R_4 and R_5 completely united, M_1 running to apex, free; M_2 free, M_3 short-stalked with Cu_1, Cu_2 absent; 1st A very weak but traceable, but anal space much broader than usual in the Gelechiidae; 2d A deeply forked at base. Hind wing trapezoidal, wider than fore wing, fringe ⅗; Sc closely parallel to R on basal half of cell, the cross-vein (R_1) not visible, R and M_1 stalked moderately, M_2 curved and approximate to M_3, which is connate with Cu_1; Cu_2 arising at ⅗, 1st A and 3rd A rudimentary, 2d A weak; no fringe on Cu.

Genotype *Brachmia (?) fulvidella* Walsingham.

Schistonoea fulvidella Walsingham (p. 120). Coamo Springs, Apr. 9, 10, Isabela, Apr. 24, Santurce, Mar. 23 (Hoffman), San Germán, Apr. 16, Dorado, May 30 (Hoffman); Puerto Real, Vieques Id., Apr. 29; Culebra Id. (Busck—NM). St. Thomas, Charlotte Amalia, Aug. 11 (Leonard). The U. S. National Museum has a closely related species from Haiti, with R_3 of fore wing hardly stalked.

ŒCOPHORIDÆ

[**Hypercallia** Stephens

Palpus long, upturned far beyond vertex, third segment much shorter than second, both with tufts on upper side near apices, but the third with a fine apex extending beyond the tuft. Antenna very shortly ciliate. Wings very broad, squarish (variable in form in the

genus); R_4 and $_5$ forking over apex, Cu_2 strongly curved, and rather close to Cu_1 at origin. Hind wing M_2, M_3 and Cu_1 shortly spaced at origin.

A true Œcophorid, related to *Cryptolechia*. The genus is wide-spread, but missing from the United States and Canada. The only known larva bores in stems of *Polygala;* possibly the Antillian species may be found on the "Violet-tree" (*Phlebotaenia*).

Hypercallia rosacea new species (pl. XLII fig. 18)

Purple-brown. Head and thorax largely mixed with red and yellow; fore wing with costal edge red, costa with yellow patches near base, before middle and at ¾; a cluster of white and yellow antemedial spots, and a white slightly raised bar at end of cell, outlined with blackish below, but surrounded with yellow and red brown; all the markings outlined in red. Fringe on upper ⅗ of outer margin yellow with red basal line, the rest dark gray. Hind wing pinkish. 17 mm.

Haiti: Petionville, June 13 (Fulda), type in Cornell Univ. collection, no. 1060; Santiago, Cuba, June (Schaus), two paratypes in U. S. National Museum. The Cuban specimens are somewhat smaller and paler, and have a round white dot at the end of the cell, corresponding to the lower end of the bar; they presumably represent a distinct subspecies.]

[*Ethmia notatella* Walker (p. 133). Haiti: Petionville, May–June (Fulda).]

E. kirbyi Möschler (p. 133). Coamo Springs, Apr. 7.

E. confusella Walker (p. 134). Common. Coamo Springs, Apr. 4–10, San Germán, Apr. 16–17, Puerto Real, Vieques Id., Ap. 28–29.

[*E. abraxasella* Walker (p. 134). Haití: Petionville, May–June (Fulda).]

Ethmia joviella Walsingham

1897. *Ethmia joviella* Walsingham, Proc. Zool. Soc. 1897, p. 90.

Smaller than the other Porto Rico species. White; fore wing with about eight black dots; hind wing gray with white fringe. 14 mm.

Grenada. P. R.: Isabela, Apr. 24; Río Piedras, Sept. 21 (Leonard).

Triclonella rhabdophora Forbes (p. 135). (Pl. XLII fig. 20). Puerto Real, Vieques Id., Apr. 28–29, common.

COLEOPHORIDÆ

Coleophora pulchricornis Walsingham (p. 138). Coamo Springs, Apr. 4–10; Puerto Real, Vieques Id., Apr. 28.

At least two other species of Coleophora were taken, which I believe new.

GRACILARIIDÆ

Spanioptila spinosum Walsingham (p. 141). Coamo Springs, Apr. 4–10.

Acrocercops sanctaecrucis Walsingham (p. 141). Coamo Springs, Apr. 10, Las Cruces (Cidra), Mar. 28. Mr. Busck tells me *A. undifraga* Meyrick, from Haiti (Exot. Micr. iv, p. 47), bred from Solanum torvum, is a synonym of this species.

A. albomarginata Walsingham (p. 142). This species was described as a *Coriscium*, but transferred by Meyrick to *Parectopa*. It shows the tibial armature of *Acrocercops*, and no doubt belongs there, where the triangular palpus is a normal feature. I suspect that *P. attenuatum* should also be transferred to Acrocercops.

P. R.: Coamo Springs, Apr. 5, 6.

Acrocercops pontifica new species (pl. XLII fig. 24)

Ochre yellow, marked with silver. Head white, sides yellow above eyes; palpus long, slender, upturned; cream, shading into ochre toward base, a gray dot at tip of second segment; maxillary palpi minute; antenna light brown, half longer than fore wing; thorax white in center, ochre on sides; abdomen gray above with a golden gloss; shaded with yellow on sides, white below with oblique subventral brown stripes. Hind legs with several rows of long fine spines above, the upper spurs at 1/6. Fore tibia and tarsus fuscous, vaguely banded, middle tibia and tarsus dirty white, with fuscous bands; hind tibia light yellow with a white tip, tarsus white with golden bars on segments.

Fore wing bright ochre, costal half marked with two light lead-gray lines, bordered with darker lead-gray; a stripe from base of costa, gradually curving away from costa and ending in upper part of cell at 3/5 length of wing; a very oblique straight line at 3/4; dorsal half with a silver white stripe from base to 5/6, divided into three parts by the ochre ground, the first section narrow, the other two equally broad and divided by a very oblique stripe; a lead fascia across apex, narrowed in the middle, turning in at inner margin and joining the apex of the silver white stripe; a black apical dot. Fringe light gray, becoming white on dorsum, with a lead gray basal line around apex. Dorsal fringe and hind wing mouse gray. 9 mm.

Apparently related to *A. leuconota* Z. from Colombia. In that species the shoulders and base of the fore wing are gray-brown, and the dorsal stripe is only once interrupted.

Porto Rico: El Yunque, Apr. 23, Cornell Univ. type no. 1061.

Acrocercops cymella new species (pl. XLII fig. 23)

Palpi slender, upturned, close-scaled, the third segment slightly blade-like; maxillary palpi obsolete; spines of hind tibia short and fine, the spurs at 1/6;

antenna much longer than fore wing. White, somewhat shining. Second segment of palpus and antenna luteous; head and thorax immaculate, abdomen light gray, paler below with traces of oblique banding. Fore legs luteous, banded with light brown, the last two segments white; hind leg white, apex of tibia with a blackish patch, and segments marked with fuscous.

Fore wing white, marked with shining fuscous gray, middle fifth occupied by a fuscous patch, which breaks into coarse striae at inner margin; a smaller and intenser patch at ⅚, breaking into two striae at each margin; three coarse wavy striae between the two patches, the first partly fused with the median patch; and a blackish apical spot. Fringe and hind wing with fringes light fuscous. 13 mm.

A striking species. Porto Rico: Coamo Springs, Apr. 10; Cornell Univ. type no. 1062.

Acrocercops zebrulella new species (pl. XLII fig. 21 male, 22 female)

Palpus rather stout with segments marked, not tufted; maxillary palpi obsolete; antenna longer than fore wing; hind tibia strongly spined above and weakly below, the upper spurs at ¼; first two segments of middle and hind tarsi with whorls of spines, cream, shaded with pale gold or buff.

Male. Fore wing (pl. XLIII, fig. 10), obliquely truncate at apex, the actual apex being far below the axis of the wing. Head pale gold; palpus with second segment more or less infuscated, third with two fuscous bars, the more basal practically covering the basal half of the segment; antenna with two blackish bars on scape, shaft yellowish, annulate with fuscous; thorax with blackish bars across front of disc and base of scutellum. Fore wing light buff, marked with dull black; costa yellowish, with a series of seven black bars on basal half, the first basal, 5th and 6th slender with the ground whitish between them, 7th strongly oblique out; dorsal part of wing with some thinner bands to correspond, the first and second with whitish ground between them, also the 3rd and 4th, which almost join the 5th and 6th costals; 5th bar thicker, oblique, and running into the oblique fascia across the wing; middle of wing with a straight oblique fascia from beyond middle of costa to before middle of inner margin, dividing into two bars at costa; a round black (blue iridescent) dot on lower edge of cell (at origin of Cu_2), followed by two parallel oblique black bars in disc and two across apex, these last not reaching margins. Apex beyond last bar deeper buff; fringe cream, the basal part buff with strong violet iridescence. Apical spot not definitely present, but violet apical portion showing as an indefinite black spot in some lights. Hind wing mouse gray; abdomen mouse gray above, below whitish with several oblique lines, the last one blackish and the others buff.

Female. Palpus pale with two dark rings. Fore wing normal in form, symmetrical; antenna with pale apex, and two pale segments, the 9th and 11th from the apex. Ground of fore wing varied, yellow and white, without distinct blue or violet iridescence; the basal and median bands indescribably confused, but more or less corresponding to those of the male; the oblique median one not really traceable, and represented on the costa by 3 or 4 stout striae; the following black dot obsolete; the two oblique fasciae less longitudinal; the subapical pair of fasciae reaching the margins, and the first one double; spining on legs weaker.

Legs in both sexes with black bars, the second segments of middle and hind tarsi with a much stronger bar than the first segments. 7 mm.

A striking little thing; obviously near *A permixtella* Wlsm., but evidently differing in the blackish markings on appendages and thorax, and in details of pattern. I know of no comparable case of sexual dimorphism in the group.

Porto Rico: El Yunque, Apr. 23, type male and paratype male and 2 females, Cornell Univ. type no. 1063.

I have three more species of *Acrocercops* from Porto Rico not suitable for description.

Gracilaria aeneocapitella Walsingham

1892. *Gracilaria aeneocapitella* Walsingham, Proc. Zool. Soc. 1891, p. 539.

1897. *Gracilaria aeneocapitella* Walsingham, Proc. Zool. Soc. 1897, p. 152.

Tawny, the costa except at base golden yellow, with purple iridescence and dark brown flecking, especially on costa and toward apex.

St. Vincent. P. R.: Lares, Sept. 20 (Seín).

LYONETIIDÆ

An undetermined species was taken on El Yunque, Mar. 29.

Compsoschema Walsingham (p. 145). Fletcher considers this genus a synonym of Lyonetia.

OINOPHILIDÆ

Ereunetis lanceolata Walsingham should be transferred to *Comodica* Meyrick, distinguished by the separation of R_4 and $_5$ on the fore wing, and the following references should be added:

1881. *Argyresthia zebrina* Butler, Ann. Mag. Nat. Hist. (6) vii, p. 403, (which has priority).

1907. *Ereunetis zebrina* Walsingham, Fauna Hawai. i, p. 715, pl. xxv, fig. 16.

1914. *Comodica lanceolata* Walsingham-Durrant, Biol. Cent.-Am. Lep. Het. iv, p. 346.

Ereunetis aeneoalbida Walsingham, (p. 148). San Germán, Apr. 16; Aguirre, Aug. 1 (Leonard).

Three more species of *Ereunetis* were taken, but not in condition to describe.

PSYCHIDÆ

Oiketicus kirbyi Guilding (p. 150). Dorado (case only).

TINEIDÆ

Porto Rico and Vieques would appear to be rather rich in Tineidæ, especially of the fungus feeding and scavenger types. The material of the Tinea group proves to have several types of structure, and so I am using several genera. I am not at all sure that I have correctly interpreted all of them and the placing should be viewed as tentative, but at present our entire classification of the family should be viewed as a merely temporary scaffold. As to the geographical distribution of the various types nothing can safely be concluded as yet, and it must not be assumed that species standing now for somewhat superficial reasons in one genus are necessarily closely related in fact; but in an old family like the Tineidæ world-wide distribution is much more to be expected than in a more modern one like the Tortricidæ, and I am inclined to believe that several of these genera will really prove of world-wide distribution.

The primitive group typified by *Eudarcia* is of special interest. In my Lepidoptera of New York I included them in the Incurvariidæ, with which their possession of a full coat of aculeae seemed to associate them. We now have females of the genera *Meessia*, *Eudarcia* and *Protodarcia* and find they have already developed the modern reproductive system characteristic of all the higher Lepidoptera from the Tineidæ up, while the Incurvariidæ have quite a different type. So we must consider these forms as practically Tineidæ, but they will certainly make a distinct primitive group almost worthy of family separation. It is interesting that Porto Rico not only has a distinct genus of this group, with three species already known, but also that its species of two more genera show a few surviving aculeæ on the disc, while the Tineidæ dominant in the temperate zone have lost them completely.

The following key will separate those genera which would run to the genus *Tinea* in the former one:

8. Fore wing with R_2 and R_3 stalked as a result of the loss of the closing vein of the accessory cell; antenna with two whorls of scales to each segment; wing membrane aculeate---------------------------*Protodarcia*

Fore wing with R_2 and R_3 arising separately from the cell, or from an accessory cell distinctly closed at its outer end; antenna with a single whorl of scales on each segment except near base; wing membrane rough, but not aculeate, or only about basal part of cell-------------- 9

9. Fore wing with R_5 and M_1 stalked from end of cell, or floating free and pointing in such a direction that if extended they would meet well beyond end of cell; hind wing with cell open below M_3, veins very weak__ 10
Fore wing with R_5 and M_1 arising separately from cell; hind wing with cell formed__________ 11
10. Fore wing with all veins present, eyes large__________ *Homostinea*
Fore wing with one vein lost, eyes small__________ *Achanodes*
Fore wing with two veins lost, hind wing with one__________ *new genus*
11. Head and hind tibia with short vestiture, fore wing with R_1 arising beyond middle of cell__________ *Lepyrotica*
Head and hind tibia with long hair, R_1 typically arising near base______ 12
12. Hind wing narrower, with sinuate costa, and cell close to inner margin, fore wing with 2d A simple__________ 13
Hind wing broader; fore wing with 2d A forked at base__________ *Tinea*
13. Hind wing very narrow, with deeply sinuate costa, Sc reaching margin well before middle; fringe about 4__________ *Mea*
Hind wing lanceolate; Sc ending at ¾; fringe less than 2__ *Infurcitinea*

Setomorpha insectella Fabricius (p. 152). Río Piedras, in wasp nests (Seín). A general scavenger.

New genus, new species

A specimen each from Coamo Springs and Palmas Abajas (Hoffman), but not in condition to describe. (Pl. XLV fig. 11).

Achanodes Meyrick

Similar to Tinea. Antenna with pecten. Fore wing (pl. XLV, fig. 13), with one dorsal vein lost (M_3); R_5 and M_1 forking over apex; 2d A simple; hind wing narrower, fringe about 2, lanceolate, without sinuate costa, and Sc long; M_1 and M_2 stalked, forking over apex, M_3 associated with them; Cu separate, widely forked. In the Porto Rico species the antenna is smooth-scaled with one whorl to a segment, the eyes are small, and in the fore wing R_4 and M_2 arise from the base of the stalk of R_5 and M_1.

Besides the following I have a species from Orlando, Florida, which is very close to *A. sympathetica* Meyrick if not the same. It is similar to the following, but is smaller with weaker veins, M_1 and $_2$ of the hind wing being obsolescent. The hind wing is without sex-scaling.

Achanodes antipathetica new species

Dull ochre or light wood brown, more or less dusted with fuscous. My material comes in two quite distinct colorings, but there appears to be no difference in structure or markings. The series are mostly females, but the three males represent both forms.

Light form. Head dull light brown, between clay color and wood brown, with a certain proportion of fuscous hairs; palpus concolorous, with a contrasting fuscous patch occupying all but the tip of the third segment, but second segment

pale; antenna concolorous, barred for a greater or less distance on the outer side with blackish, the *pedicel* (narrow second segment) large and contrastingly blackish. Thorax and fore wing rather evenly dusted with light fuscous, without any markings, grading into a darker shade along costa, and with the costal edge nearly solidly fuscous. Hind wing in male completely covered with dense sex-scales, those on the costal ⅔ large and pointing obliquely down and out, then a narrow zone of smaller nearly longitudinal scales and inner margin with a series of long scales pointing up and out for half the length of the wing, and a second set overlying the fringe on the basal fifth or so. Female hind wing grayish, normal. Fore and mid tibiae and tarsi fuscous with luteous tips of segments and a bar across middle of tibia.

Dark form. Identical with light form in sex-scaling and markings, but head darker brownish fuscous, of a mixture of shades, and fore wing heavily dusted with fuscous, the costa rather broadly solid fuscous. 9 mm.

Porto Rico: Santurce, Mar. 25 (Hoffman) holotype male (light); paratypes from Coamo Springs, Apr. 4–10 (both light and dark); Isabela, Apr. 24 (both); Dorado, June 15 (Hoffman) (light); San Germán, Aug. 20 (Leonard) (dark), San Juan, Aug. 30 (Mills); Puerto Real, Dec. 12 (Leonard); Vieques Id., Apr. 29, (dark). Cornell Univ. type no. 1064.

Homostinea Dietz

Similar to *Tinea*. Fore wing (pl. XLIV fig. 12) very narrow, with veins R_5 and M_1 stalked (the stalk obsolete in the Porto Rico species, leaving the veins floating), the stalk normally out of the base of M_2, but free in the South American *H. (Nystrologa) invidiosa* Meyrick. Hind wing with cubital stem entirely free from medial, in the Porto Rico species running close to inner margin and obscurely forked; all the veins being hardly more than deflections of the wing-membrane.

Only 3 or 4 species are known, all American.

Homostinea tischeriella (p. 156 as *Tinea*). One of our specimens is very fresh and has a purple iridescence on the dark part of the fore wing. The antenna has the scaling decumbent and is light gray, only appearing annulate under a low power.

El Yunque, Mar. 29 (rubbed); Apr. 22 (fresh).

Infurcitinea Spuler

Similar to *Tinea*, but with 2d A of fore wing (pl. XLIV fig. 14) simple at base. Hind wing typically with M_1 and $_2$ stalked but approximate in *I. bimaculella*.

The following species are put here on venational characters; they do not look much like the type, the European *I. argentimaculella*.

The North American "*Tinea*" *bimaculella* is not a Tinea, but is fairly close to the Porto Rico species. *Meessia*, to which Fletcher sinks the genus, has aculeate wing-membrane, and is hardly distinct from *Eudarcia;* the following species has a small patch of aculeae about the base of the cell, as in some other Tineid genera. The *granella* group of Tinea has a good deal the same wingform, but the costa of the hind wing is sinuate.

Infurcitinea palpella new species

Dark clay color or light wood brown, dusted and marked with grayish fuscous; head wood brown, darker about the edge of the eyes and base of antennae; palpi heavily mottled with blackish, tending to form blackish bars on each segment, bristles black; maxillary palpi also barred; antennae mouse gray, the single row of scales covering the outer ¾ of each segment; the narrow naked bases appearing as pale annulations with low power; scape blackish with paler pecten. Thorax wood brown dusted with blackish, the tegulae blackish with pale tips, and contrasting. Fore wing broad, heavily dusted and shaded with fuscous, especially on the costal half, where the fuscous may be nearly solid; base of costa blackish, sometimes connected by an oblique shade to the first dark spot in the fold; fold with two large vague squarish nearly black patches, the ground more yellowish before and between them; a similar patch beyond middle of cell, with a patch of the lighter ground between it and end of cell; end of cell with a slight dark mark. Outer part of wing more coarsely mottled, the dark tending to gather in a spot in middle; fringe concolorous, dusted with light scale-tips. Hind wing and abdomen light gray. 8 mm.

There is quite a little variation in the relative amounts of ground and fuscous, but the three dark spots are always distinct in light specimens and the three corresponding pale ones in dark specimens. *Infurcitinea bimaculella*, from the U. S., is related, but is larger and more brilliant, and has M_1 and $_2$ free.

Porto Rico: Puerto Real, Vieques Id., Apr. 28–29 (type and paratypes); Cataño, May 16 (Leonard and Mills) paratypes. Cornell Univ. type no. 1065.

Infurcitinea luteella new species

Hind wing with M_1 and M_2 stalked.

Luteous, head with a few brown hairs at base of antenna only; palpi lightly infuscated on outer side of second and third segments, the maxillary palpi with very little fuscous; antenna gray, paler than the preceding, deep fuscous at base. Thorax heavily dusted with fuscous, the shoulders blackish; fore leg with pale rings on all segments, femur lightly infuscated. Fore wing heavily dusted with fuscous, especially toward apex, fringe concolorous; hind wing light gray. 8 mm.

Porto Rico: Puerto Real, Vieques Id., Apr. 29; type and paratype, Cornell Univ. no. 1066.

Lepyrotica Meyrick

Similar to *Tinea.* Head with short vestiture; palpus as in Tinea, antenna ¾ fore wing, close-scaled; hind tibia rough-scaled below only, smooth above. Fore wing with R_1 arising beyond middle, Cu_2 from angle of cell; hind wing with M_1 and $_2$ stalked; fringe ⅕. The genus is monotypic.

Lepyrotica scardamyctis Meyrick

1921. *Lepyrotica scardamyctis* Meyrick. Zool. Meded. vi. p. 199.
1927 *Lepyrotica scardamyctis* Meyrick, Exot. Micr. iii, p. 326.

White, dusted lightly with gray, with a few gray flecks and black dots, the most persistent being in the cell (several in female, one in male). 13 mm.

Bermuda. "Leeward Islands" (Von Hedemann—Meyrick). Von Hedemann collected mainly in St. Thomas and St. Croix; as in several cases Meyrick has recorded this material as if from the Leeward Islands, it is probable this is another case, and that the material really came from the Virgin Islands.

Mea Busck

Similar to Tinea; antenna with one whorl of long scales to each segment, covering the segment. Fore wing (pl. XLIV, figs. 16, 17) narrow, cell nearer dorsal than costal margin; M_2 and $_3$ stalked, Cu_2 sometimes obsolescent. Hind wing nearly linear, fringe 4, costa deeply sinuate, with Sc ending before its middle, all veins separate though weak.

A small North American genus. The following species will fall in the group with *M. bipunctella*, and the genus will probably also include "*Tinea*" *cretella* from Haiti, which seems closely related to *M. incudella*.

Mea incudella new species (pl. XLII fig. 26)

White with black markings. Head with tuft white, the face blackish, shading into wood brown below, especially on the bases of the hairs; palpi black on outer side, with black bristles; antenna over ¾, shining lead gray, not annulate. Thorax white with black shoulders.

Fore wing chalky white; an irregular black patch on basal third of costa, widest beyond its middle, and followed immediately by a small longitudinal black bar before middle of costa; a black triangle opposite end of cell, bounded by vein R_3, with a raised black discal dot below it; outer part of wing beyond cell dusted with light brown scale-tips, the dusting extending in along inner margin far toward base. Fringe whitish with blackish scale-tips, which gather to form a small dark apical fleck. Hind wing light gray, with light brown fringe. 9 mm.

Porto Rico: El Yunque, Apr. 22–23, Mar. 29, type and paratype; Santurce, Mar. 25 (Hoffman), paratypes. Cornell Univ. type no. 1067.

Mea yunquella new species (pl. XLII fig. 25)

Similar to the preceding species, larger, heavier, the hind wing wider with more sinuate costa.

Cream color or bone white, marked with black. Vertex cream; facial tuft including area between antennae black, the hair-bases paler; palpi mostly black, maxillary palpi pale, the two terminal segments whitish, contrasting; antenna lead-gray, scape black; thorax cream, the tegulae with pale apices.

Fore wing cream, shading into light red-brown outwardly and toward inner margin, the part beyond the cell more mottled, rough-scaled, and shading into the blackish apex. Costal area black, contrasting, its lower boundary very irregular, widened broadly at about ⅓, and triangularly at apex of cell, very narrow between, and almost interrupted by some short whitish striae. Inner margin vaguely shaded with blackish except at base, widening into a spot at ⅔ and a smaller one opposite end of cell; a black discal dot. Outer margin vaguely barred with groups of whitish scales, especially near anal angle. Fringe pale brownish gray, the basal half flecked with blackish; hind wing and fringe light brown-gray. 10 mm.

Porto Rico: El Yunque, flying about the face of a cliff near the summit; Mar. 29. Cornell Univ. type no. 1052.

Another white species of *Mea* with gray dots, and one vein lost in fore wing (pl. XLIV fig. 17) may possibly be *Tinea fragilella* Wlsm., described from Haiti.

Tinea pallidorsella Zeller (p. 156). The ground is wood brown, and in our fresh specimen the dark flecks show a distinct violet iridescence. El Yunque, Apr. 22.

T. brevistrigata Walsingham (p. 157). R_1 arising from cell at about ¾, well beyond the base of the obscure accessory cell, a small patch of aculeæ in base of cell; hind wing broad, with long Cu_1 and $_2$ and long-stalked M_1 and $_2$. Puerto Real, Vieques Id., Apr. 28–29. Aguirre, Apr. 2–3, 1931 (Leonard and Mills).

T. scythropiella Walsingham. Structure much as in the last species. El Yunque, Apr. 23, Palmas Abajo, June 23 (Hoffman); Cataño, May 16 (Leonard and Mills); Puerto Real, Vieques Id., Apr. 28–29, not rare.

T. familaris Zeller (p. 159). A true Tinea (pl. XLIV fig. 15), with R_1 arising near base, and well before the distinct accessory cell, no aculeæ, and M_1 and $_2$ of hind wing separate. Coamo Springs, Apr. 9, Puerto Real, Vieques Id., Apr. 28, 29.

Protodarcia new genus

Fully aculeate. Head densely hairy, especially on front; antenna smooth with *two* regular whorls of scales to each segment, the outer one only a little erected, nearly as long as fore wing, pecten present; ocelli not seen; palpi with second joint with some loose hair-scales and a terminal whorl of bristles, third fusiform, scaled; maxillary palpi folded, much longer than in Tinea, being nearly as long as labials; hind tibia with long hair above and below; female abdomen with two terminal segments telescopic, membranous, and each provided with a pair of tendons as in Tinea and higher forms, ovipositor membranous, with fine sense-setae; vagina separate from oviduct.

Fore wing lanceolate, the apex of membrane somewhat extended (pl. XLIV, figs. 18–20); R_1 arising at 2/5, R_2 and R_3 stalked by the loss of the end of the accessory cell; R_5 and M_1 stalked from end of cell, forking over apex (unlike *Eudarcia* and *Meessia*); one dorsal vein lost, the rest free and subequal; 2d A simple at base. Hind wing 2/3 with fringe 3; costa sinuate with Sc short; M_1 and M_2 connate and approximate to R; cell open below them, and M_3 lost, the point of closure of the cell marked by a slight angulation in Cu_1; Cu_2 and the part of Cu_1 beyond the angulation short.

This description is based on *P. bicolorella*, the genotype. The other two species have suffered further reduction and may be separated generically when the group is better known. The combination of stalked R_2 and $_3$, R_5 and M_1, separate this genus from any known Tineidæ or Incurvaridæ, save *Demobrotis* from Australia, which is perhaps related. I suspect that *Tinea plutella* Walker, described from Venezuela, also belongs here.

The larva of *Meessia* lives in a flat case, and feeds on lichens; that of the Australian *Demobrotis* in a cylindrical case.

The genotype is *P. bicolorella*, described below.

Protodarcia bicolorella new species (pl. XLII fig. 27)

Structures as given in generic description.

Head black above, face white, with some gray hairs above mouth; both palpi blackish, the bristles on labials black; antenna dark gray, faintly annulate, becoming black at base. Thorax white, the anterior edge and shoulders blackish; fore legs blackish in front, with only tip of tibia pale, middle legs dark gray and hind legs pale gray with tips of segments whitish. Fore wing dark gray, mottled with black, and outwardly with whitish; dorsal third occupied with a white stripe which lies mostly below the fold, but is extended across to the costa at base, and before the anal angle shortly crosses the fold, and is nearly cut into three rounded spots by extensions of the black ground; costa with whitish bars, extending across fringe; dorsal fringe mottled with whitish and nearly black, with a suggestion of barring. Abdomen and hind wings light gray. 7 mm.

A striking little thing, with a noticeable resemblance to *Tholerostola evippella.*

Porto Rico: Coamo Springs, Apr. 4–7 (type and paratypes); San Germán, Apr. 16; Aug. 20 (Leonard), Río Piedras, Aug. 23 (Leonard), and Puerto Real, Vieques Id., Apr. 29, paratypes. Cornell Univ. type no. 1068.

Protodarcia argyrophaea new species (pl. XLII fig. 28)

Antenna ¾ fore wing, more slender, with outer whorl of scales more raised; maxillary palpi much longer than labials, the latter with weak bristles; bristles on scape disorganized, hardly forming a pecten; fore wing as in *P. bicolorella;* hind wing narrower, fringe rather less than 3; similar to *P. bicolorella,* but with M_1 arising out of base of free part of R, M_2 approximate and Cu simple, two veins being lost.

Tuft white, mixed with light gray; face blackish on sides, becoming solidly blackish above mouth; palpi luteous with some fuscous on tips of labials; antenna luteous with scape whitish, and shaft with a dark dorsal line, of alternate black and very dark gray rows of scales; thorax whitish with gray-brown tegulae. Fore legs mixed black and white, middle and hind legs largely white, shaded with very pale brown. Fore wing light gray-brown, with irregular silvery white transverse lines; some confused marks at base, first line at ¼, irregular, erect; second at middle, forked at costa; third to anal angle, forked toward the anal angle and sending its outer branch to outer margin; fifth short, costal, sometimes joining the outer branch of the fourth; a short stria across apex, enclosing a blackish apical area. Fringe with a blackish basal line on costa and apex, cut by the last two silver lines. Hind wing and abdomen pearl gray. 7 mm.

A striking species, which would seem to come very near to Demobrotis. Meyrick describes the latter genus as having two dorsal veins lost on the fore wing and 2d A forked at the base.

Porto Rico: Coamo Springs, Apr. 10, type and paratype, Cornell Univ. type no. 1069.

Protodarcia plumella Walsingham (p. 159, as *Tinea*). Maxillary palpi longer than labials. Fore wing with closing vein of the accessory cell from stem of R_{2+3} to R_4, barely visible in a favorable light; R_4 connate with R_5 and M_1; hind wing with M_1 and $_2$ connate, barely separated from R; Cu simple, very weak, free. San Germán, Aug. 20 (Leonard). (pl. XLIV fig. 20).

Acrolophus (Pseudanaphora) arcanellus Clemens

1859. *Anaphora arcanella* Clemens, Proc. Acad. Nat. Sci. Phil. 1859, p. 262; Tineina N. Am. pp. 57, 58, 1872.

1887. *Pseudanaphora arcanella* Walsingham, Trans. Ent. Soc. Lond. 1887, p. 170.

1900 *Pseudanaphora areanella* Dyar, Can. Ent. xxxii, p. 310.

1924. *Acrolophus arcanellus* Forbes, Cornell Mem. lxviii, p. 121.

Palpus rather higher than vertex, and leaning only a little backward; eyes hairy, with a horizontal fan-like tuft of lashes in front; veins all separate; male antenna moderately laminate. Male genitalia with uncus of two well separated spines, gnathos divided and valves nearly simple, rather truncate at ends. Fore wing fuscous, mottled and spotted with blackish. 20 mm.

There is some local variation, which may prove worth race names on further study, especially as there seem to be corresponding very slight differences in the genitalia. Jamaica has another race or very closely related species. The Porto Rico specimen is small and more contrastingly marked than usual, but is nearly matched by one from Cayamas, Cuba.

Eastern United States. Cuba (U. S. National Museum). P. R.: Río Piedras, Aug. 28 (Mills).

Pseudanaphora new species (p. 162). Aguirre, May 22 (Leonard).

Acrolophus triatomellus Walsingham (p. 163). Six specimens from Puerto Real, Vieques Id., (3 male 3 female) appear to belong to this species. They are very close to my *triformellus*, but in all three males the first segment of the midtarsus is close-scaled, while in *triformellus* it has some hair on the upper side, and the tuft on the tibia appears to be much smaller also. Superficially the three males show the vertical series of white scales mentioned by Walsingham, and one also has several scattered white scales on the veins toward outer margin. The genitalia are like those of *triatomellus* (fig. 8 of the first report) but seem a little more hairy and more heavily constructed.

Another specimen from Puerto Real, which is very large and dark and has more heavily developed lashes, may represent a third species of this group.

A. triformellus Forbes (p. 163). A series of this species from San Germán tend strongly to a reddish ground, and may turn out to be *walsinghami* Möschler. Only a study of the genitalia of the type can settle the matter. In this species the white at the end of the cell is a single rounded dot, a diffuse patch, or absent. Fresh specimens of the light form may show a distinct rosy costa. All the metatarsi have distinct hair-tufts on the upper side.

Acrolophus (Acrolophus) harparsen new species

1892. *Acrolophus vitellus* Walshingham, Proc. Zool. Soc. 1891, p. 512, pl. xli, fig. 11 (male genitalia) (P. R. record).

1897. *Acrolophus vitellus* Walsingham, Proc. Zool. Soc. 1897, p. 173 (P. R. record).
(not *Acrolophus vitellus* Poey, from Cuba)

Eyes hairy, as in the group *Pseudanaphora*, but unlike the remaining Porto Rican species of Acrolophus; with a horizontal fan-like tuft of bristles in front of the eye, as in *A. arcanellus*. Antenna short, broad and simple, not serrate; palpi turned back to rear of thorax, second segment with a spreading tuft at tip, third with a triangular tuft on the upper (morphologically ventral or posterior) side, this tuft larger and looser than in *A. triformellus*. Lashes behind eye strong, normal. Fore and middle tibiæ short, with dense tufts on outer sides, fore tarsi merely thick-scaled, mid-tarsi close-scaled; hind tibiæ densely hairy as usual, the first two segments of tarsi also with dorsal hair. Fore wing with all veins separate. Female with palpi porrect, the first two segments triangularly scaled, and third broadened below; fan of lashes in front of eye weaker than in male, and disappearing in rubbed material; male genitalia (pl. xlvii fig. 45) with uncus simple but minutely bifid at tip, gnathos simple, penis with two spines, and valve broad and upcurved.[1]

Male dull dark fuscous brown, in faded specimens wood brown, obscurely mottled and transversely striate; with vague darker spots in middle and near end of cell, and triangular spots extending down cross cell near base and at middle, alternating with the dark spots in cell; the basal of these two triangles defined on outer side only, and both diffuse above. Region beyond cell paler, the subterminal region vaguely darker; costal edge with about a dozen dark striæ; fringe concolorous. Hind wing very slightly grayer; the concolorous fringe with a fine pale basal line. *Female* fore wing with ground paler, the brown spots in cell and triangles across fold contrasting, the striæ on costa narrower and darker, and the pale and dark outer part of the wing separated by a nearly straight diagonal boundary running to the apex. Male 20 mm., female 28 mm.

Porto Rico: Lares, Nov. (Seín; type and paratype male); San Juan (reported as *mimasalis* Walker ?); Río Piedras, Apr. 21 (flown female); also a series in collection of the Insular Experiment Station, presumably from Río Piedras, fresh but faded. Cornell Univ., type no. 1070.

[1] In the species which I identify as the true *vitellus* (pl. XLVII, fig. 46) from Habana, the uncus and gnathos are both double, and one of the two penial spines is minute. Another species in the National Museum from Santiago must also be considered, but seems to me less likely to be the true *vitellus*. It has the uncus and gnathos double, but with the lobes in contact, the valves hooked at the tip, and penis bifid with a single massive spine. The Porto Rican species appears so far not to occur on Cuba at all.

A. ochraceus Möschler (p. 162). Río Piedras, Apr. 23, Santurce, Apr. 15, Cataño, May 16 (Leonard and Mills).

MEGALOPYGIDÆ

Megalopyge krugii Dewitz (p. 166). Coamo Springs, Apr. 7, Dorado, June 30 (Hoffman), Cataño, July 24 (Leonard and Mills).

NEPTICULIDÆ

Nepticula gossypii Forbes and Leonard (p. 168). South coast from Guayanilla to Yauco (mines, and imagoes bred by Leonard). Apr.

Nepticula species. Coamo Springs, Apr. 9.

EXPLANATIONS OF THE FIGURES

PLATE XLIII

Venations

Fig. 1. *Heligmocera calvifrons* female.
Fig. 2. *Saphenista multistrigata*
Fig. 3. *Stilbosis phaeoptera*
Fig. 4. *Eriphia pernigrella*
Fig. 5. *Aphanosara planistes*
Fig. 6. *Tholerostola evippella*
Fig. 7. *Anacampsis bifuscella*
Fig. 8. *Stegasta capitella*
Fig. 9. *Schistonoea fulvidella*

PLATE XLIV

Venations

Fig. 11. Tineidae: new genus, new species
Fig. 12. *Homostinea tischeriella*
Fig. 13. *Achanodes antipathetica*
Fig. 14. *Infurcitinea palpella*
Fig. 15. *Tinea familiaris*
Fig. 16. *Mea incudella*
Fig. 17. *Mea*, new species
Fig. 18. *Protodarcia bicolorella*
Fig. 19. *Protodarcia argyrophaea*
Fig. 20. *Protodarcia plumella*

Plate XLV

Male Genitalia

Fig. 21. *Olethreutes anthracana*, ventral view, opened out
Fig. 22. *Gymnandrosoma trachycerus*, same
Fig. 23. *Heligmocera calvifrons*, same
Fig. 24. *Epinotia unica*, same
Fig. 25. *Saphenista lepidulana*, same; penis figured separately
Fig. 26. *Saphenista semistrigata*, same
Fig. 27. *Saphenista multistrigata*, same
Fig. 28. *Phalonia subolivacea*, same

Plate XLVI

Genitalia

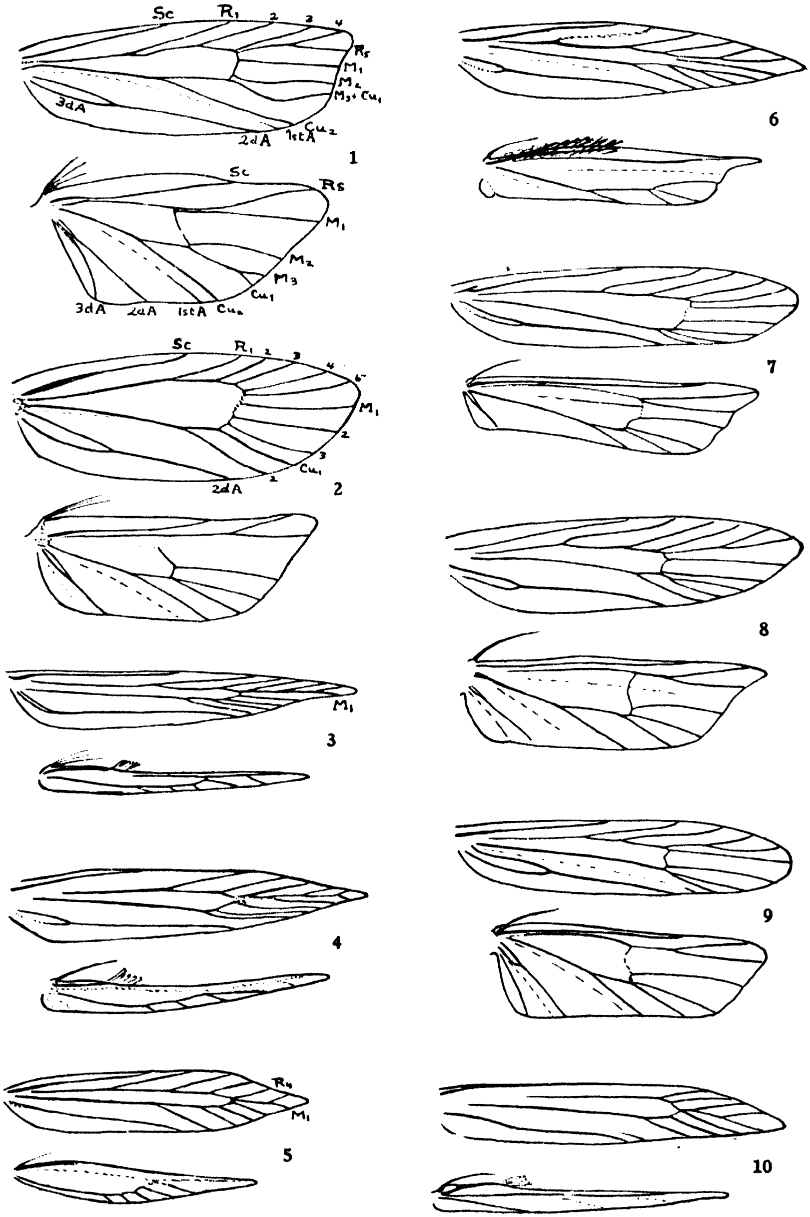
Fig. 29. *Eriphia pernigrella* male; general view from ventral side—cleared but not dissected, to show position of organs
Fig. 30. *E. pernigrella;* main part of genitalia, opened up on the right side and spread out
Fig. 31. *E. pernigrella*, penis
Fig. 32. *E. pernigrella;* dorsal half of 7th abdominal segment
Fig. 33. *E. pernigrella;* ventral half of 7th abdominal segment
Fig. 34. *E. curvipunctella* male; eighth segment opened out latero-ventrally, uncovering the true genitalia in ventral view
Fig. 35. *E. quinquepunctata;* male; ventral view, showing parts in position; to the same scale as fig. 29.
Fig. 36. *E. pernigrella* female, ventral view
Fig. 37. *Aphanosara planistes* male, lateral view
Fig. 38. *Glaucacna iridea* male, ventral view opened out, penis omitted
Fig. 39. *G. iridea* male, penis and associated sclerite (juxta ?)

Plate XLVII

Male genitalia

Fig. 40. *Aristotelia vagabundella*, side view, with eversible tufts on eighth segment
Fig. 41. *A. vagabundella*, somewhat larger scale, showing details
Fig. 42. *Aristotelia diolcella*, side view
Fig. 43. *Aristotelia lignicolora:*—the penis is drawn to the same scale
Fig. 44. *Aristotelia absconditella*, valve and penis (U. S.: Conn.)
Fig. 45. *Acrolophus harparsen* (*vitellus*, Walsingham). Side view; the uncus and gnathos are unpaired. Porto Rico.
Fig. 46. *Acrolophus* sp. from Habana, Cuba. Perhaps the true *vitellus;* ventral view, opened out, showing the double uncus and gnathos.

PLATE XLIII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R1
2
3
4
Rs
M1
M2
M3+Cu1
3dA
2dA
1stA
Cu2
1
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Rs
M1
M2
M3
Cu1
3dA
2dA
1stA
Cu2
Sc
R1
2
3
4
5
M1
2
3
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2dA
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M1
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R4
M1
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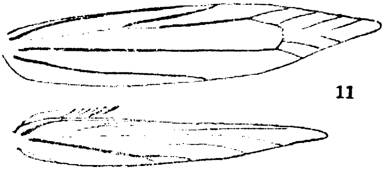
PLATE XLIV



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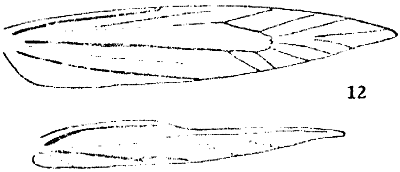

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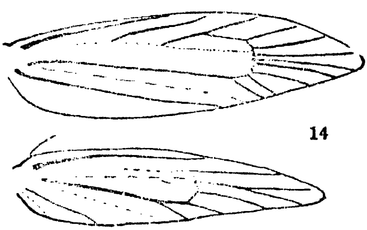

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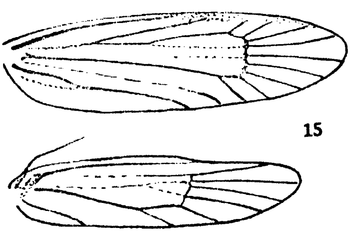

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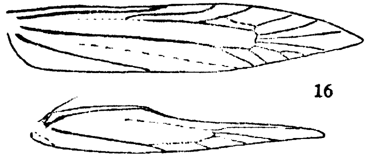

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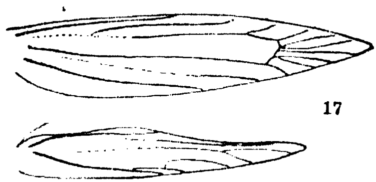

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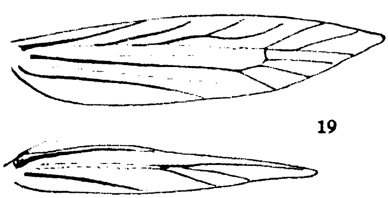

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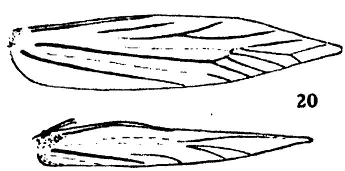

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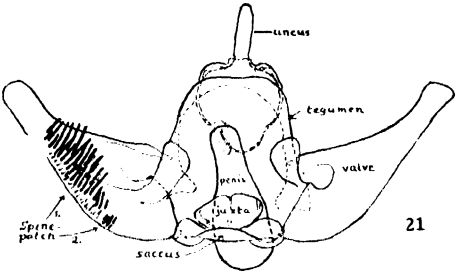
PLATE XLV



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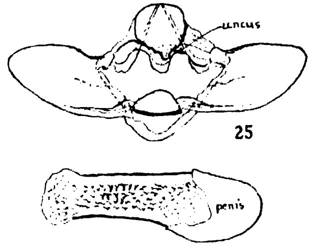

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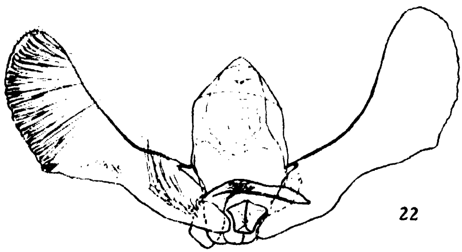

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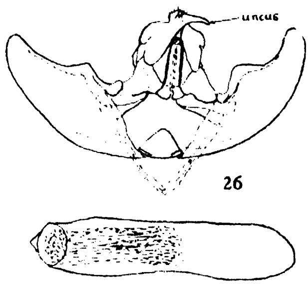

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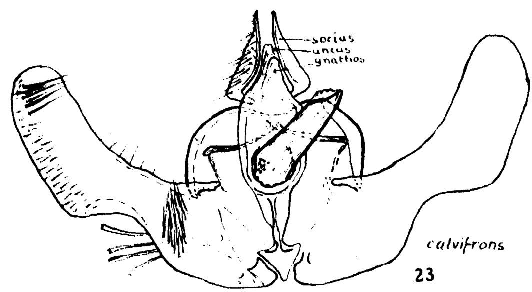

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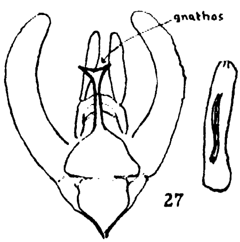

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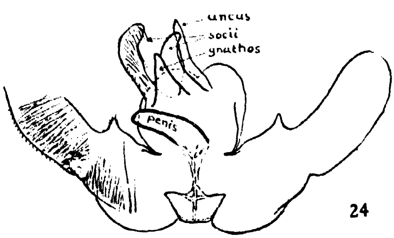

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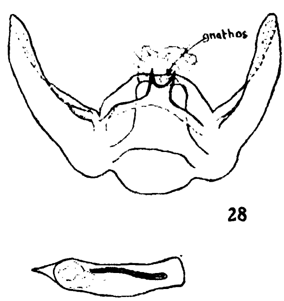

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PLATE XLVI

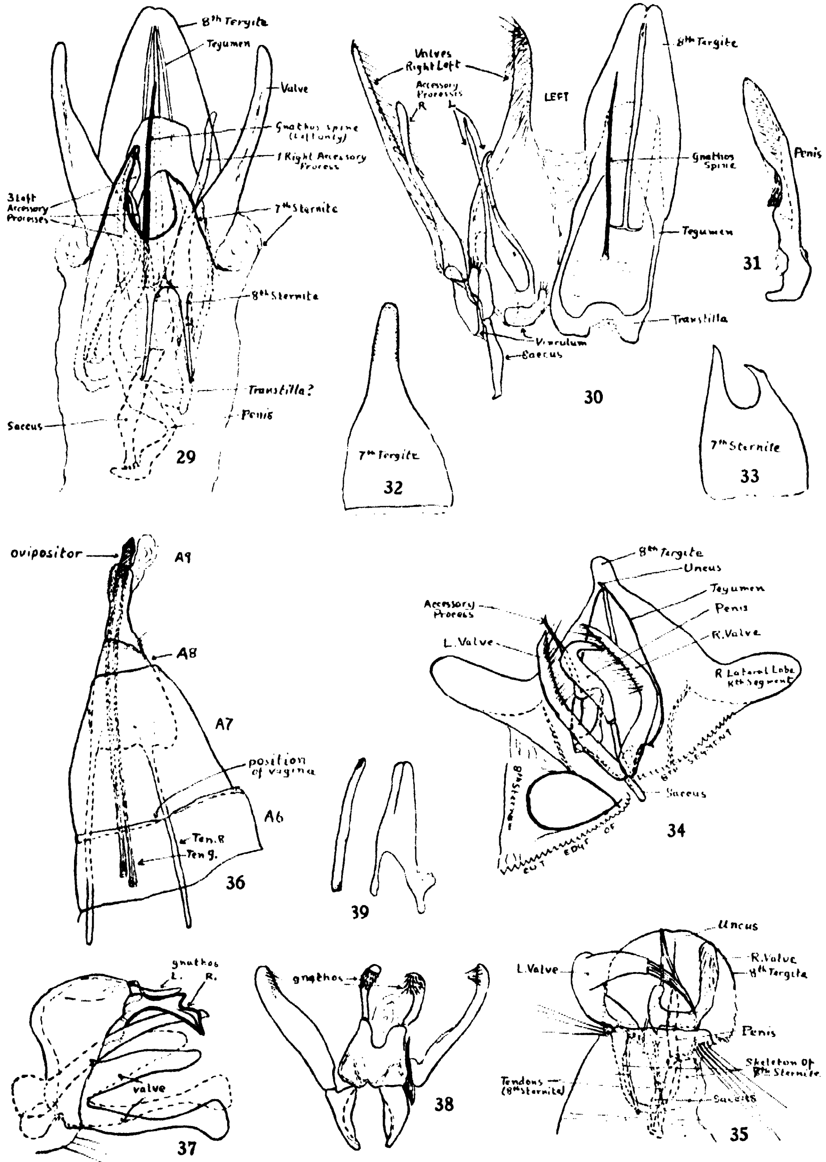
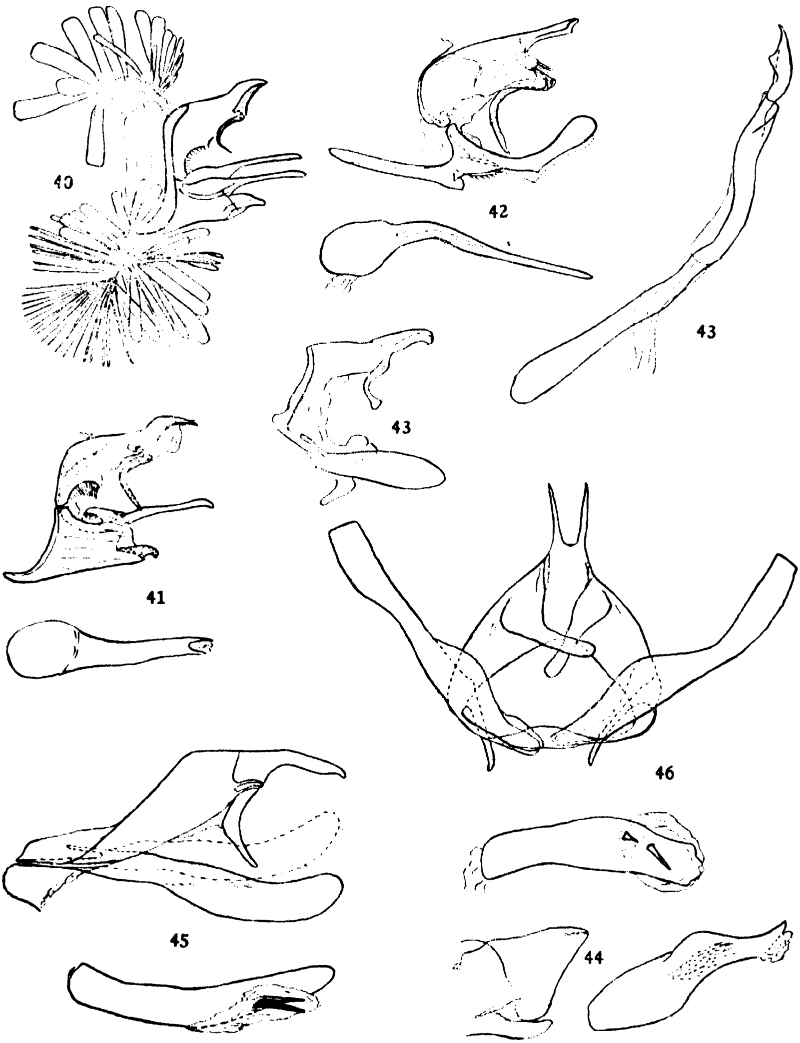

8th Tergite
Tegumen
Valve
Gnathos spine (Left only)
1 Right Accessory Process
3 Left Accessory Processes
7th Sternite
8th Sternite
Transtilla?
Saccus
Penis
29
Valves Right Left
Accessory Processes R L
LEFT
8th Tergite
Gnathos Spine
Tegumen
Transtilla
Vinculum
Saccus
30
Penis
31
7th Tergite
32
7th Sternite
33
ovipositor
A9
A8
A7
position of vagina
A6
Ten. 8
Ten 9.
36
39
8th Tergite
Uncus
Tegumen
Penis
R. Valve
Accessory Process
L. Valve
R Lateral Lobe 8th Segment
8th SEGMENT
Saccus
CUT EDGE OF
34
gnathos L. R.
valve
37
gnathos
38
Uncus
L. Valve
R. Valve
8th Tergite
Penis
Skeleton Of 8th Sternite
Tendons (8th sternite)
Saccus
35

PLATE XLVII



THE INFESTATION OF YOUNG OKRA PODS BY PINK BOLLWORM IN PORTO RICO

By GEORGE N. WOLCOTT, Entomologist, Isabela Sub-Station.

SUMMARY: Infestation by *Pectinophora gossypiella* Saunders of tender young okra pods, not more than three inches long, nor more than three days old, occurs in Porto Rico when the okra plants are close to cotton fields maturing bolls which are heavily or totally infested by pink bollworm.

The average annual rainfall in the northwestern corner of Porto Rico is usually sufficient so that most of the agricultural crops of the Island could be grown there if the distribution of the rainfall thruout the year was not so uneven, and the periods when most of it occurs were not so uncertain. During the last few years, irrigation water has been available in this section, the Isabela Irrigation District, but the extremely low and unsatisfactory prices received by growers for cotton and sugarcane, the main crops of the region, make desirable the introduction of other more profitable crops.

One of the most promising developments appears to be the production of vegetables for the winter market in New York, and several kinds of vegetables have already been grown here, and exported on a small scale. Among others which gave promise of being profitable was okra, but the importation of okra pods from Porto Rico into continental United States is prohibited by federal quarantine. As the market demands for okra require pods to be not more than three inches long, it seemed possible that such tender and recently developed pods might escape infestation by the pink bollworm, *Pectinophora gossypiella* Saunders. Thus, an investigation for the collection of pertinent data seemed desirable, looking towards the possible formulation of a request for a modification of this quarantine.

The sole record of infestation by pink bollworm of okra pods in Porto Rico (1), at the time the writer commenced work on vegetable insects this spring, was that made by Mr. J. D. More at Humacao in 1921, when pink bollworm was first discovered in the Island. The Plant Quarantine and Control Administration agents stationed in Porto Rico for a number of years since had added nothing but negative evidence to this lone record, and it seemed likely that infestations were most exceptional. The illustration of caterpillars in pods, given by Loftin in his publication on this insect in Mexico (2) were of large, mature pods, and when questioned in person, he stated that

he had no remembrance of finding the larvae in the smaller pods. Several okra pods examined at various points between Isabela and Aguadilla, at a time when cotton plants had not yet begun to mature bolls, gave further negative evidence. Indeed the first positive indication that okra might be infested was an observation made at the opposite end of the Island.

While making examinations of cotton bolls to determine the amount of infestation by pink bollworm, in one rather extensive planting near the beach east of Loíza Viejo, infestation was found to be not only total for the bolls, but so heavy that all the bolls were destroyed. The grower explained that the first crop of cotton grown here had been so excellent and profitable that he had promptly followed it with another planting immediately after plowing up the first, which, most inexplicably to him, had proved to be a complete failure. By thus having no non-cotton season, he had built up such a large population of pink bollworm in this comparatively isolated region that it was not surprising to find that a single okra plant nearby with mature green pods was infested with its caterpillars, four pods having one larva each, and one pod containing two caterpillars. This observation, however, represented a most exceptional condition, and none of the smaller pods were infested, even of this plant in the midst of a large moth population presumably experiencing the greatest difficulty in finding suitable hosts for oviposition. Yet it indicated possibilities, which were later confirmed by Messrs. Mills and Berry, of the Plant Quarantine and Control Administration, who are unofficially reported to have found ten out of sixteen pods of okra infested at Trujillo Alto in a small planting adjacent to a cotton field known to be heavily infested with pink bollworm.

The real point at issue, however, had not been determined: whether the immature green pods would be infested. Observations made at the Isabela Sub-Station indicated that pods attained the maximum marketable size in three days from the dropping of the corolla, and ordinarily pods must be picked every other day to keep them from becoming too tough to be acceptable to the market. The period when they might possibly become infested before being picked was so short that it was thought that in commercial plantings infestations would not occur. To determine this point with certainty, a considerable planting of okra was made, consisting of a row around the cotton fields of two demonstration farms of the district, at Maleza and at Bejucos. The cotton on both of these farms was beginning to mature at the time the okra was planted, and while it was known to be infested with pink bollworm, these infestations were supposed to be

representative of near-by commercial cotton fields, and of the district as a whole.

The farm at Bejucos is in the midst of a cotton district, and later observations have indicated that pink bollworm was not exceptionally abundant there. The farm at Maleza, however, is in a region previously devoted largely to growing hat palms, and while scattered patches may be planted to cotton, the farmers generally know little about its culture. It is presumed that no care had been taken at the end of the previous crop season to destroy old cotton plants from one of these near-by patches, and the fertilized cotton of the demonstration farm was noted to be heavily infested with pink bollworm as soon as it began to mature bolls. By the time that the okra plants began to form pods, infestation of cotton bolls by pink bollworm was total. Nevertheless, the first two pods of okra attaining marketable size at Maleza were free from pink bollworm injury, as were the next fifty, nor were eggs observed on any of them.

The next collection of okra pods from Maleza was made July 30th, but their examination was not commenced until August 1st, and the smallest pods were not cut open until the 3d. The longest of these pods were 5 inches in length, 20 out out of the total of 176 being from 5 to 4.5 inches long, 20 from 4.5 to 4 inches, and 20 from 4 to 3.5 inches long, but the remainder were of the most desirable marketable size, or even smaller, being less than 3 inches long in some cases. In two of the largest pods larvae already beginning to turn pink were found. Smaller caterpillars were found in the younger pods, but the percentage of infestation did not greatly decrease with a decrease in the size and presumptive age of the pods. For the total collection, infestation was about 6 per cent. Observations made five days later at Maleza gave results practically identical with those previously obtained there: an infestation of about 6 per cent. From over a hundred pods collected there the next day, of which the majority were examined, only one was found infested with pink bollworm, but this pod was only two and a half inches long.

In the meantime okra pods attained marketable size at Bejucos and indeed had grown so luxuriantly that some of those of tender age were much too large, some of them being seven inches long. Despite their large size, none were infested with pink bollworm (Aug 3d). Five days later, all of one hundred pods, from six to three inches long, were free from pink bollworm injury.

These results would appear to indicate that, while under ordinary conditions, infestation of okra pods does not occur even in the midst of cotton fields with normal pink bollworm infestations, even the

youngest pods may become infested when near-by cotton is heavily infested. Such heavy infestations in cotton fields may be so readily built up by inexperienced or careless growers as to constitute a perpetual threat to commercial okra production. Naturally, of course, any reasonable hope of expecting possible changes in quarantine regulations governing okra must be abandoned.

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1. **Wolcott, G. N.** Insectae Portoricensis. Jour. Dept. Agr. P. R., Vol. 7, No. 1, pp. 313. San Juan, January, 1923. (see p. 202.)

2. **Loftin, U. C., McKinley, K. B. & Hanson, W. K.** Report on Investigations of the Pink Bollworm of Cotton in Mexico. U. S. Dept., Agr. Bull. No. 918, pp. 64, fig. 11, pl. 5. April 19, 1921.

A NEW SPECIES OF ARISTELLIGER FROM NAVASSA

CHAPMAN GRANT, Major, U. S. Army

Aristelliger cochranae sp. nov.

Type: No. 2320, male, Chapman Grant Collection. 30 May, 1931. Navassa Island; Collector, Crew of L.H.T. "Acacia".

Diagnosis: A gecko of moderate size, the basal half of each digit expanded and provided beneath with unpaired lamellae, the distal half of the larger digits compressed, curved and provided with a claw at the tip; upper side and chin covered with small granules; underside from neck to tip of tail covered with larger imbricated smooth scales. No femoral pores. A distinct black spine on vestiginal eyelid, twice the length of head granules. Body longitudinally striped. Tail cross barred.

Habitat: Navassa Island, off the S W tip of Santo Domingo.

Proportions: Adult, 50 mm. snout to vent. 65 mm. vent to tip of tail. Center of eye slightly in front of center between ear and snout. Ear diamond shaped; as large as first infralabial. Angle of mouth turns up behind eye, then horizontal again. Head broader than neck. Legs short and thick, femoral joint equal to snout to center of eye. Tail round, firm, strong. Eye large, pupil vertical; edges of pupil smooth, not wavy.

Squamation: Rostral deeply creased centrally almost to lip; extends slightly over and laterally on snout. A pair of internasals, separated by one or three scales. Nostril lateral, touching rostral, internasal and postnasal which in turn lies on first supralabial. Ten supralabials; seven and a half to center of eye. Mental, a quadrant. Eight infralabials, first three about half depth of mental. Two postmentals form a right angle inclosing base of mental, followed laterally by two more scales each one half the size of the one preceding. Three or four rows of slightly enlarged, elongated scales border the infralabials. Remainder of throat to neck, covered with small granules. Neck to tip of tail, covered with somewhat larger, smooth, imbricated scales. A barely discernible escutcheon of slightly concave scales anterior to vent of males. All upperside covered with granules, about eleven in diameter of eye. A distinct black spine, occasionally two, on vestiginal eyelid, twice the length of head granules. Legs and feet covered with granules similar to back. The basal half

of each digit expanded and provided beneath with eight or nine unpaired lamellae forming an oval followed by narrower lamellae to base of digit. The distal half of the larger digits compressed, curved, and provided with a claw at the tip.

Color and markings: Above, brown; dark stripe bordered with light from snout, crosses eye and runs to shoulder on female and to sacrum on male. Tail bears about nine narrow dark crossbands followed by light bands of the same width, more pronounced on males. Sides marbled. Chin of male marbled; of female white. Belly light or white. Underside tail; female, white; male, dark. Digit pads ash. A regenerated tail is diagonally penciled with jagged lines. Color of young specimen: Snout to vent 20 mm. Beginning at nape, seven light diamonds to sacrum, ten on tail. Dark stripe from snout crosses eye and is then broken outlining diamonds. The young have a decidedly checkered appearance in contrast to the striped adults. The change is apparent through medium-sized specimens.

My small series of seven adult to medium sized and six young make it impossible to state definitely whether there is a fixed sexual dichromatism.

Remarks: Named in honor of Doris M. Cochran.

EXPLANATION OF PLATE NO. XLVIII

Aristelliger cochranae sp. nov.

1. Medium sized male.
2. Adult male. Note full-length stripes.
3. Note pattern of regenerated tail.
4. Adul female. Note stripes stopping at shoulder.
5. Young. Note checkered pattern.

Illustrations life size.

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PLATE XLVIII.

1. 2. 3. 4. 5.